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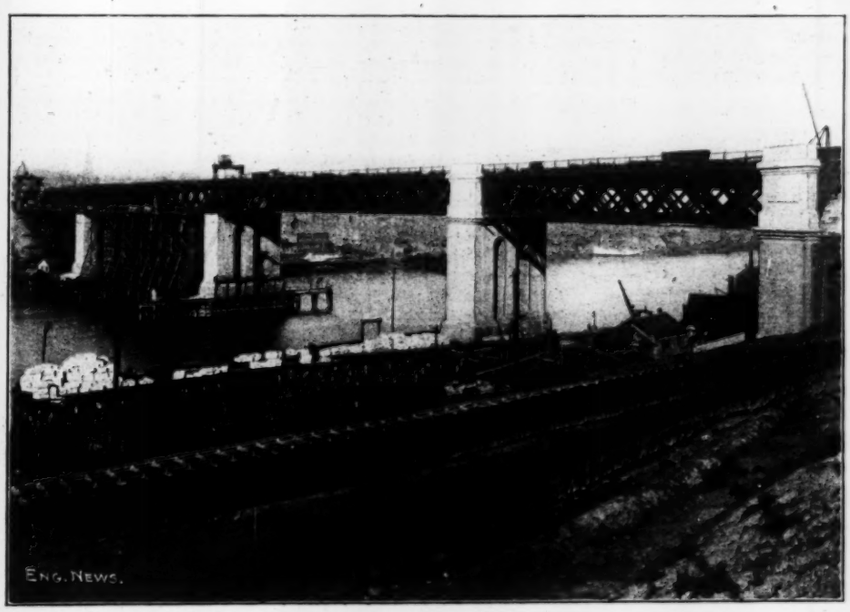
FOUR-TRACK DECK BRIDGE OVER THE TYNE AT NEWCASTLE, ENGLAND.

A new railway bridge over the River Tyne at Newcastle, which has just been opened to traffic, represents one of the largest pieces of bridge work done in England since the construction of the Forth Bridge. The structure is of no mean magnitude, since it is a four-track structure, of two spans of 300 ft. each and two spans of 191 ft. and 231 ft., respectively. The photographic view on this page exhibits the general character of the structure well, but a few remarks on its design and construction may be of service.

The railway traffic across the river has hitherto been carried by the so-called High-Level Bridge, opened in 1849. The track connections of this bridge required through trains going either north or south to back out of the Newcastle Station. The new bridge will enable trains to run through the station without changing direction. The bridge is approached on the north, or Newcastle, side by a masonry viaduct of ten 25-ft semi-circular arches, connecting with the tracks running out of the Newcastle Central Station. On the south side, the railway crossing the bridge forks into two branches; one, leading to the east, joins the main line of the Northeastern Railway near the Gateshead Locomotive Works, while the other, leading west and crossing above the Northeastern Railway's Redheugh Mineral Branch, joins the main line to the south. The division into two branches begins on the last (southern) span of the bridge and requires here the unusual expedient of a "spread" span. The south approach comprises several masonry arches of 35 to 50 ft. span, and a short steel girder span.



GENERAL VIEW OF NEW HIGH-LEVEL BRIDGE OVER THE RIVER TYNE AT NEWCASTLE, ENGLAND.

The original design for the bridge contemplated three spans of steel trusses—respectively, 231 ft., 300 ft. and 300 ft., going from north to south—flanked by masonry arch viaducts. During construction, troublesome conditions of the subsoil of the south side led to the addition of a fourth span of 191 ft. adjoining the original three. All of the trusses are at such a level as to give 83 ft. clear height above high water in the Tyne. This is the same clearance as provided by the Old High-Level bridge and the Redheugh (highway) bridge, respectively below and above the new bridge.

The steelwork of each span comprises five double intersection latticed trusses 27 ft. deep, spaced 11 ft. c. to c., and braced together. The upper and lower chords of these trusses are riveted sections 36 ins. deep by 54 ins. wide. Each web system has a panel length of about 46 ft. and the spacing of the two systems is therefore about 23 ft. The trusses are of riveted construction throughout. An expansion roller-bearing is provided at one end of each truss. Hand-railings 5 ft. high are riveted to the outer edge of the top chord of the two outside trusses. The width of the bridge, center to center of hand-rails, is 48½ ft. At the pier ends of the trusses, the top chords are bracketed out to within 6 ins. of similar extensions on the trusses of the adjacent span so as to provide continuous metallic support for the roadbed. The weight of steelwork in these spans is: North, 950 tons; central spans, 1,741 tons each.

The southern span, as already noted, is a spread span. Its north or pier end is 44 ft. wide between centers of outside trusses, the same as in the other spans, but its southerly or abutment end has a spread of about 128 ft. This span has five trusses, like the others, but the three inside ones are only 24 ft. deep, so as to carry a ballast floor on steel trough flooring. The trough flooring is 16 ins. deep and spans a varying distance, from 7 ft. at the pier to 28 ft. at the abutment. It is filled with concrete, in which the ties are bedded. This span contains 1,350 tons of steel.

The substructure of the bridge consists of cut-stone piers founded on concrete-filled steel caissons sunk by the pneumatic process. The foundation work involved unusually large caissons; the horizontal dimensions of one of them (the three were exactly alike except in height) was 113 ft. length, by 35 ft. in breadth, the ends being beveled off at 45°. The piers themselves measure 103½ ft. long at the cut-water and 68½ ft. at high-water, where the shaft of the pier begins. All three caissons were sunk to a level 69 ft. below high-water.

The center-pier caisson was 26 ft. high above the cutting edge, so that the pier masonry extends to 43 ft. below high-water or about 28 ft. below low-water. The north and south caissons, 56 and 53 ft. high respectively, extend to about low-water level. The shells were of ½ to 5/16-in. steel plate with a ⅞-in. plate for cutting edge; they were braced with steel framing for a height of 26½ ft., and with timberwork above this level. The working chamber was 8½ ft. high at the center and 7 ft. at the sides, 4½ ft. from the outer edge, whence sloping plates ran down to the cutting edge. Two transverse girders, with their bottom flanges 3½ ft. above the cutting edge, furnished a safety-pocket provision in case the caisson dropped suddenly. Air pressures up to 36 lbs. were used in sinking the caissons.

The temporary caissons, for enclosing and laying dry the masonry work up to water-level, were also made of steel plating, braced with timber. They were bolted to the tops of the permanent caissons, with rubber-packed joint, and were removed by divers when the masonry was above water.

A complication of an unusual kind was encountered in building the south abutment of the spread span. In sinking the foundation pits it was found that the ground of the river bank was honeycombed with very ancient coal workings, of considerable extent. These had to be filled with brickwork, where they extended under the site of the abutment, before its construction could proceed.

The erection of the superstructure was carried out on a timber platform wide enough for two trusses. When the first two trusses of one span had been "swung," the platform was shifted to erect the others of the same span, the work being done one span at a time. Fig. 2 gives a typical view of the erection of a 300-ft. span.

For handling material in the construction of this bridge, a cableway spanning from bank to bank was set up, and used with great success. Fig. 3 shows one of the towers. The span was

Fig. 2. Erection of 300-ft. Span of New High-Level Bridge at Newcastle. Two Trusses Completed; Bottom Chords of Third and Fourth Being Laid Down on Falsework.

1,520 ft., the main cable was 3 ins. in diameter, and the capacity of the hoist was 10 tons. Electric power operated the cableway.

The bridge was designed and erected by the Cleveland Bridge & Engineering Co., of Darlington, England.

RAILROAD REGULATION BY LAW IN MEXICO.

By Erdis G. Robinson.*

Since at the present time the question of railroad regulation by law and the part the government should take in fixing rates to be charged for transportation service is being very generally discussed and thoughtfully considered, it is interesting, and possibly may be made profitable, to study the experiences of other nations and the laws they have framed to deal with this important matter. It is proposed in the present paper to call attention to the really excellent railroad law in operation in the Republic of Mexico, and to mention some of its most striking provisions. To be sure, the problem in that country with its 13,000,000 people served by 13,000 miles of railroads does not become involved in the intricacies that would follow the enactment of a similar law in this country, but probably the question is one of comparative complexity. At any rate, in Mexico there seems to have been an honest attempt to frame a law which, while not discouraging the building of railways nor hampering their operation, will still protect the interests of the public.

If in studying the Mexican railroad laws the laws of this country may at times seem by comparison to appear at a disadvantage, it should be considered that here the growth of the railway system has been contemporaneous with the development of the steam locomotive, while in Mexico the first railroad was constructed after the locomotive had passed through its experimental stage and had been brought to a high order of excellence. And while any large system is thus growing from a small beginning, it is exceedingly difficult to foresee the needs of certain regulating laws; and after the time has arrived when laws are needed to properly protect the public interests, it is then well-nigh impossible to have them enacted, so powerful are the influences friendly to the orgnaizations that have grown up at the same time. The process of law-making is generally too slow to keep pace with the phenomenal growth of large business corporations.

But the lawmakers of the southern republic have been able to profit from the experiences of the United States and other countries. Also they have profited from their own experiences and have revised their laws as occasion has seemed to demand. And right here may be seen how a paternal or an autocratic form of government may work to the advantage or disadvantage of the people of a country according to the wisdom and honor of its ruler. Mexico, although nominally a republic, has been governed or dominated during the entire period of its railroad growth by one man, who has worked sincerely for the national advancement; and as there is no large middle class whose wishes must be consulted and whose will, expressed by actions of Congress, must be obeyed, this man has been able to have carefully prepared and then quickly enacted laws which in this country could have been established only after years of debate in Congress and perhaps the overthrow of a political party.

The law under which the railroads are operated in Mexico went into effect in 1899-1900, and covers the entire range of railroad business, from the organization of the company to its final operation. All the railroad companies, except small and private lines, operate only under concessions granted by the government; these concessions cover certain points in a general way for all companies, and other points with especial reference to each company.

It may be of interest to note first some of the general provisions of the law, applying alike to all companies:

(1) It is provided that materials of construction used by the railway companies may be admitted into the country free of duty. The importance and value to the railway companies of this provision may be appreciated by any one familiar with the workings of a protective tariff, such as prevails in Mexico as well as in this country. In this connection it is interesting to note that because of this exemption from customs duty by the Mexican Government, as compared with the high rates of our own tariff law, the Mexican railroad companies are able to purchase, delivered, certain articles of construction manufactured in this country at prices below those paid by the purchasing agents of our own roads. This refers especially to steel rails and heavy construction hardware.

(2) Another clause of the general law provides that although no monopoly is to be encouraged by the government, still, under certain circumstances, it may during a term of years refuse a concession to a road which would parallel and compete with an existing road, and decline to admit free of duty materials to be used in the construction of such road. The enforcement of this clause of the law would prevent the construction of roads for speculative purposes, as well as those whose operation would lead to certain ruinous competition. It is easy to recall instances where such a law might have been enforced in this country with decidedly beneficial results, stopping the buildings of lines whose construction has led only to consolidation and accompanying higher rates and over-capitalization.

(3) Again, by this law the government is given the right to stop the operation of any road organized under a concession, if it considers that sufficient precautions have not been taken to ensure the safety of the passengers and employes. This brings to mind laws passed in this country for the same purpose, which led to the adoption of improved couplers, brakes and the other safeguards in our railroad service.

(4) Perhaps the most interesting of the general provisions is that which limits the life of each concession to 99 years and provides that at the end of such period the real property of a company, such as rights of way, stations, piers, warehouses, shops, office buildings, etc., shall pass into the possession of the state in good condition and free from all encumbrances. At such time the nation must purchase the rolling stock and appliances at a fairly appraised value. And in order that the railroad co[mpany] not take advantage of the nation at [the end] is provided that the latter shall be [entitled to] the earnings of the company for a [period of five] years preceding the close of the life [of the con]cession.

Although the law thus provides f[or the pass]ing of the railroads into the posses[sion of the] state at the close of the period of the [concession,] yet it is more than likely that the [government] will, at such time, renew the lease o[f roads] to the former owners. For few of t[he roads,] any, have been constructed under [a single] sion and at one time, but rather, a[s] branch lines or extensions have [been] under several concessions expiring [at] years. And the confusion that would [result from] the operation of parts of one railw[ay system] under different owners having differen[t interests] during the interval between the exp[iration of] the first and last concessions, would m[ake it de]sirable to again lease to the former o[wners the] road affected by the expiration of the c[oncession.] At such times, however, the governme[nt would] be in a position to alter the terms of [the con]cessions in any way thought desirable [and to] the interests of the public. For no doub[t it will] be decided at such time that the influen[ce of the] government may better be exerted throu[gh wise] regulation than by direct operation and [ownership] of the transportation companies.

Among the subjects specifically covered in the railway concessions as required by law may be mentioned:

(1) A definition of the territory to be covered by the proposed road, with a statement of its terminal cities, etc.

(2) Regulations for the conduct of surveys, with the time for beginning and ending the work.

(3) The number of miles to be constructed annually.

(4) The amount of subsidy, if any, to be paid to the company by the government.

(5) Time for the completion of the work.

(6) A schedule of maximum rates to be charged for the transportation of passengers and freight,

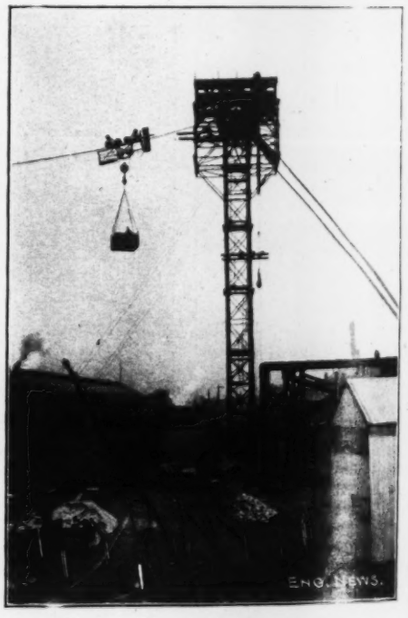


Fig. 3. South Tower of Cableway Used in Erection of New High-Level Bridge at Newcastle.

and for the telegraph, baggage and express service.

Two of the above items (4 and 6) may seem to be of sufficient interest to merit further description below.

Concerning the matter of subsidies it is well to note that the condition confronting the Mexican government has been similar to that of our own government at the time of the construction of the Pacific railroads, when the vast terri-

*515 West First Ave., Columbus, Ohio. Late of the Engineering Department of the Mexican Central Ry.

tory ast of the Mississippi was largely an untra ed wild. It was then thought necessary to su lize the railroads by means of valuable land nts. This was done on the grounds that the p sperity and progress of the nation depend upon the prosperity and progress of all its di rent sections; that, to assure the proper grow of such undeveloped sections, railways were of prime importance; and that the entire coun would share in the prosperity following the r road building.

Mexico, before the advent of the railroads, was large an undeveloped country with long distanc between the centers of activity, and its prop growth could be secured only by railroad buil g. Accordingly, the government has been quit liberal in the matter of subsidies, which, pos y because there are no large tracts of publ lands, take the form of bonds of the redeemable public debt, or an equivalent. This subsidy varies in amount according to the nature of the country through which the road passes, or according to the importance of the road to the government; it is paid usually on completion of lengths of 100 kilometers. The Mexican government requires in return, however, more than to share in the general prosperity resulting from the operation of the road, as will be made evident in later paragraphs.

It has been stated that the government concessions cover, among other things, the subject of railroad rates. This, being a matter of present interest, would seem to merit a short quotation from the law under discussion. Article 93 states:

> The tariffs for railroad transportation shall include the rates for which transportation is to be done and the conditions according to which the companies bind themselves to effect such transportation, and shall be subject to the following rules:
> (1) The tariffs, the classification of merchandise, and the conditions for transportation shall be approved by the Department of Communications and Public Works, and shall be made public.
> (2) The applications of the tariffs shall always be effected on a footing of most perfect equality, save in cases where the law authorizes the reverse.
> (3) All railroad companies must revise their tariffs and present them to the Department of Communications and Public Works for its approval every three years.
> (4) If when the tariffs are revised the Department of Communications and Public Works shall consider that they can be reduced without damage to the interests of the company and if the company will not agree to the reduction, they may nevertheless be reduced by as much as ten per cent.; but the company shall be guaranteed the increase which on an average has been obtained in the last five years.

In addition to these regulations are provisions for freight tariffs on a decreasing scale, differences in tariffs due to costs of transportation over different parts of the lines, rates on carload lots, charges for long and short haul, etc. And it is expressly forbidden for the railroad company:

> (1) To make contracts whereby one or more persons are granted a lower passenger or freight rate than that authorized by the approved and published tariff.
> (2) Totally or partially to refund the amount for freight or passenger transportation collected when the contract was entered into, with a view of effecting a reduction or rebate in the tariff rate.
> (3) To give rebates in passenger or freight rates allowed out of their commissions, by agents or brokers working on commission. Such agents or brokers for all legal purposes shall be considered as employes of the company, and the sales of tickets that they may effect, or the freight contracts that they enter into, are subject to the provisions of the preceding paragraph.
> (4) To perform any act or enter into any contract of which the consequences will be to diminish or reduce directly or indirectly, the passenger or freight rates of the tariff in question.

Concerning passenger rates, before taking up the subject in a general way, it may be of interest to name the amounts which the government and one of the roads have agreed upon as proper to be charged for transportation, bearing in mind that the figures given below may not apply to all lines. For convenience of comparing with the conditions prevailing in this country, the distances will be given in miles and the rates in United States money.

First class tickets are sold at 2.4 cts., second class at 1.6 cts., and third class at 1.2 cts. per mile; and assuming that 50% more passengers travel third class than first and second class combined (which is probably well within the truth), the average rate is, for all classes, 1.52 cts. per mile—an interesting figure in view of the movements in several of the states here to secure 2-ct. fare.

Concerning passenger rates in general, the law fixes the tariffs to be charged and defines limited and unlimited tickets and round trip rates; it is especially clear in forbidding the sale of tickets by any but the authorized agents of the companies. There are no ticket scalpers in Mexico, and a traveler cannot with impunity sell his own ticket. One who has observed the strenuous efforts of our own roads, exerted through their passenger agents, to put the ticket brokers out of business will realize what a valuable concession this is to the railroad companies.

Strong condemnation is often heard of railroad combinations or pools for the purposes of distributing business, on the ground that such action prevents competition and results in higher rates. The Mexican government empowers, even encourages, the railroad companies to form such contracts among themselves whereby their earnings are pooled according to some pre-arranged proportion. Such pools or contracts, however, are subject to approval by the proper department of the government, which is therefore in a position to prevent such combinations as may seem to be harmful to the best interests of the country.

From what has preceded it would seem that the government of Mexico has tried to take a fair course between the railroad companies and the public. For instance, note that while the law may prevent the construction of lines for speculation only, or such construction as would lead to ruinous competition by the paralleling of existing lines, yet on the other hand, the favored roads cannot raise their rates, since such acts would need to be referred to and be approved by the government. Also, while the railroad companies are allowed to form pools among themselves, yet they cannot act without the consent of the government, and so cannot rob the public by concerted high rates. Furthermore, although railroad building is encourged by remitting custom duties and in other ways, yet the government has not hesitated to make requirements amounting to hardships, to assure the building of an entire line of road proposed when the concession was secured. For example, it has compelled the construction of certain roads from both ends simultaneously, causing expensive transportation charges on the materials of construction.

In this connection, it may be well to observe that the government seems to have been influenced by the railroad interests in framing the monetary law now prevailing. Until recently Mexico was a free silver country, with the price of its *peso* fluctuating, as compared with gold, from, say 35 to 55 cts. This condition was agreeable to a considerable part of the mining, agricultural and merchant classes, but it worked great hardship on the railroads, since it meant that they were receiving their earnings in the variable *peso* and buying supplies and paying bond interests in gold. By the monetary law referred to, the value of the *peso* is fixed at 50 cts. gold, so that the railroad companies are not in doubt from day to day as to the ratio between the money they receive and expend, and are able to lay their plans accordingly. No doubt the railroad managers are pleased to have the value of the *peso* thus fixed in spite of the fact that its present value is something over 50 cts. gold, which caused a corresponding loss in revenues.

In the framing of this railroad law, the government has consistently looked after its own interests (which are, of course, the people's interests), and has not permitted itself to be held up for special and high rates. For the railroads are required by law to handle the freight, passenger and telegraph business of the government at one-half the rates fixed in the various concessions, and to carry without any charge whatever all mail matter and postal officials on business. In Mexico there could be no sharp competition and close bidding, such as is common enough in this country, for the privilege of carrying the government mails.

Through its department of Communications and Public Works the Mexican government keeps well informed as to the condition of the railroad properties and the manner in which the companies are following the regulations contained in the concessions and in the railroad law. To this end numerous inspectors, "technical and administrative," in the government service observe and keep the government informed as to the conduct of surveys, operation of the roads, or the administration of the office business. These inspectors are appointed by the government and paid out of a fund collected from the railroads subjected to the inspection.

Laws that do not provide penalties for cases of violation amount to little more than advice—they may be followed or not at pleasure. To be effective laws must have ample penal provisions. The framers of the Mexican railroad law have named penalties for all infractions, these penalties usually taking the form of fines of varying amounts for each offense. The fine may be imposed upon station agent or railway president who may be shown to be guilty; and the higher the rank of the official the more severe the penalty. Punishment by imprisonment, too, is provided for in the case of certain misdeeds of railway employees; but as it is usually through the interpretation of the common law, it need not enter into this discussion. In the matter of punishing railway employees the judicial authorities are often over-zealous.

In recent years Mexico has entered the era of consolidations, now so far advanced in this country. It is perhaps well that the law outlined above has become established before the combinations of capital have grown too powerful to be readily controlled. The government has even anticipated this movement and, without waiting for the expirations of the concessions, has begun to exert over the railroads a control secured by stock purchases made in the open market or otherwise. In this way the government has already acquired holdings in a large part of the railroad mileage, and has not hesitated to use the power arising from such holdings. It is doubtful if this move is to be commended, since in cases of dispute where the government is interested in but one side of the question, it is difficult for it to be impartial. With the power given to it by this law the government would be in a position to make fair competition almost an impossibility. This condition has already brought about some interesting developments which probably will lead to the general good by extending the operating areas of the different roads and causing the settlement by compromise of certain important questions. But whether good or bad in its effects, this move on the part of the government would seem to indicate a determination to keep the upper hand, if possible, in its dealings with the railroads.

NEW PAVING AND SEWERAGE WORK AT FORT SMITH, ARK.

By George Myers.*

Municipal improvements at Fort Smith, Ark., on an unusual scale for a city of that size (population: 1900, 11,587; local estimate, 1906, 25,000) are now under way. On July 20, 1906, sewer and paving contracts, aggregating considerably over $1,000,000 in price, were awarded. The paving contract includes about 70 miles of streets, or an area of about 850,000 sq. yds. Most of the new pavements will be of brick, with sand filler, on 4 ins. of Arkansas River sand. In special cases, a 5-in. concrete foundation will be employed. Concrete gutters, each 2½ ft. in width, will be used. The pavement between gutters will range in width from 40 to 15 ft. For residence streets which are 50 ft. or more in width, a pavement 20 ft. wide is proposed. The contract price for the pavement is 81¾ cts. per sq. yd. for brick on sand, and $1.46 for brick on concrete. The brick are to be made in Fort Smith, at a plant to be erected by the paving contractors, Burke Bros., of St. Louis, Mo. The contractors have 40 months for completing the work.

*Principal Assistant Engineer, Board of Improvement, Fort Smith, Ark.

Outside of the principal business streets of Fort Smith, few of the streets are improved, the exception being three which are partly paved and some macadamized country roads.

The sewer contract, which has been awarded to the W. J. Gawne Co., of Cleveland, Ohio, for $471,454, embraces some 45 miles of sewers on the combined plan, which includes an 11¾-ft. concrete sewer. It is estimated that three years will be required to complete this contract.

At present Fort Smith has about 31 miles of sewers on the separate system, discharging into the Arkansas River. The sewage from the Poteau River district will be diverted to the new outlet, which will discharge into the Arkansas River. One of the material advantages of the extension of the sewerage system will be the surface drainage effected and the reduction of mosquitoes thereby.

In accordance with the peculiar statutes governing municipal improvements in Arkansas, the work outlined above will be done by districts, under a board of improvement. At Fort Smith the latter is appointed by the city council and is composed of Messrs. Harry E. Kelley, J. M. Tenny and Samuel McLoud. Mr. S. A. Mitchell, of Kansas City, Mo., has been chosen chief engineer to the board. Preliminary surveys for the work outlined above were begun on May 20, and the contracts were let, as already stated, on July 20. The engineering force included, besides the chief engineer, two field parties and one draftsman.

The cost of these improvements will be assessed upon property owners, who will have ten years in which to pay for the pavements and twenty years for the sewers. The assessments for the paving will be based on frontage, while the sewer assessments will be based on the area of the lots. The bonds for this work will soon be sold.

A MECHANICAL FILTER PLANT OF REINFORCED CONCRETE CONSTRUCTION AT GERA, GERMANY.

By Edmund B. Weston,* M. Am. Soc. C. E., M. Inst. C. E.

A mechanical filter plant of about 3,000,000 gals. capacity has been built for a large dyeing and bleaching establishment owned by Mr. Louis Hirsch at Gera, Germany. Reinforced concrete was used for the coagulating and subsiding basins and the filter tanks.

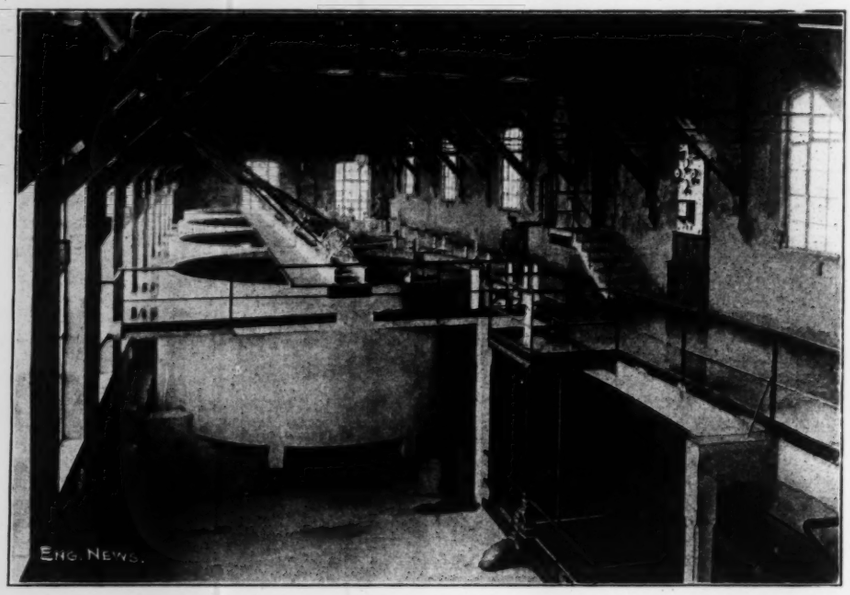
The water supply is taken directly from a canal supplied from the White Elster River. The turbidity of the raw water sometimes reaches 1,000 parts per 1,000,000. The contractors for the plant guaranteed that with a turbidity of 750 parts per 1,000,000, no turbidity could be measured in the effluent with a Jackson candle turbidimeter when the effluent was placed in a tube one meter in length. The plant was put in operation in January, 1906, and has been giving satisfaction. It is operated at the rate of 146,000,000 gals. per acre per 24 hours. The canal water flows by gravity to preliminary subsiding basins, where it remains for about three hours, coagulants being used in these basins only when deemed necessary. A low lift pump delivers the water from the preliminary basins to the regular coagulating and subsiding basins at the filter plant, where the water receives continuous coagulation and subsidence for two hours. The water then goes by gravity through the filters, a flume, and on to storage tanks.

The accompanying illustration shows the four reinforced concrete filter tanks and some of the accessories, in the filter house. The space in the foreground is reserved for two additional filters of the same size.

The wash water from the filters passes to a sludge receiver in which the heavier material settles before the water passes to the city sewers. The sludge from the coagulating and subsiding basins can also be discharged into the sludge receiver. The sludge in the receiver is emptied into carts through a pipe connection.

Sulphate of alumina is used as a coagulant, with gravity feed to the coagulating and subsiding basins, and also to the preliminary subsiding basins when necessary.

The writer, as consulting engineer of the Jewell Export Filter Co., prepared the detail plans of the filters and their auxiliaries and the preliminary plans for the coagulation and subsidence basins and filter building. Mr. E. B. Young, chief engineer for Mr. Hirsch, prepared the other plans required. Mr. E. A. Gieseler (of Berlin), general manager of the Jewell Export Filter Co. for Germany, with Mr. W. L. Lawton, Jr., as superintendent of construction, had supervision of the work done by the filter company, which included the furnishing and erection of the filter plant, with the exception of the reinforced concrete construction, and two electric motors and a centrifugal pump for washing.



GENERAL VIEW OF MECHANICAL FILTERS FOR A DYEING AND BLEACHING ESTABLISHMENT AT GERA, GERMANY.

*Consulting Engineer, 86 Weybosset St., Providence, R. I.

THE TELEPHONE SERVICE OF ITALY is being improved by the Ministry of Posts and Telegraphs, which recently appointed a commission to investigate the telephone service of the country. The telephone system of Venice was taken over by the Ministry in 1904, since which time a small fund for improving the system has been accumulating. The improvement of the service in Rome is proposed.

THE LATEST UNDERGROUND RAILWAY AT LONDON, ENGLAND.

The latest of the numerous underground railways at London, England, is the deep level "tube" line of the Baker St. & Waterloo [illegible] and has the distinction of being the first railway built across the city in a north and south direction, intersecting (but not at grade) the several east and west lines. Railways on approximately this route have been projected for over 30 years, but all former schemes have failed owing to financial difficulties or the opposition of property holders. The new line commences in the southern part of the city, near the terminal of the City & South London Ry. (the first of the "tube" lines) and connects the Waterloo and Charing Cross terminal stations on the south with the Marylebone and Paddington terminal stations on the north. The total length will be about 5¼ miles, and the line is now in operation for 3½ miles. The maximum grades are 1.66% and the sharpest curves are of 330 ft. radius. The underground railways here referred to are all for local or rapid-transit service, while the terminal stations mentioned are those of four of the trunk lines.

There are two single-track tunnels, having a clear diameter (inside the flanges of the iron lining) of 11 ft. 8¼ ins. on tangents and on curves of not less than 1,320 ft. radius; 12 ft. on curves of not less than 660 ft., and 12 ft. 6 ins. on curves up to 330 ft. radius. The stations on each line are separate, and are formed by enlarging the tunnel diameter to 21 ft. 2½ ins., one side of the larger tunnel coinciding with that of the smaller one. Ventilating fans and passenger elevators are provided at the stations. Work was commenced at a shaft on the bank of the Thames, and from this each tunnel was driven both north and south, four shields being used. A square heading 6 × 6 ft., and about 8 ft. long was driven ahead of the shield, which was then forced forward by jacks bearing against the completed lining of the tunnel. A move of 20 ins. was made with each setting of the jacks. The average rate of progress was 73 ft. per week. When the position for a station was reached, a gallery was driven up to the level of the top of the larger excavation, and a top heading driven for about 18 ft.; this heading was enlarged and the roof supported by timbering until the excavation was large enough for the iron lining. As soon as eight rings of the lining had been completed, the large shield (with 22 jacks) was erected. With these large shields no central advance heading was driven, but the excavation was carried on over the entire face, the head of the shield being divided into nine compartments or working chambers. Hydraulic erectors were used to set the lining segments in place. In passing under the river the shields had to be driven through a bed of water-bearing gravel, and here the compressed-air system was employed, special methods being adopted to prevent loss of air. When ready to advance, holes about 12 ins. square and 22 ins. deep were made in the gravel around the circumference of the shield, each causing a slight blow-out and being at once filled with clay. With a ring of clay filling thus completed, the shield was driven ahead, moving easily through the clay. The gravel face was then excavated for about 20 ins., and the new face then plastered with clay and boarded up, previous to erecting the new ring of lining. Another series of holes and clay pockets was then formed, and the shield again advanced. All cavities outside the lining were filled by cement grout pumped through holes in the iron segments.

The track is laid with ties of Australian hardwood resting on a central core or bank of concrete, but the ends (including the rail seats) project beyond this and are supported by ¼-in. granite ballast. The rails are of the English 90-lb. bull-head section, carried in cast iron chairs secured to the ties by screw spikes. The ties are 5 × 14 ins. (or 5 × 10 ins. at the joints), with a length of 6 ft. 6 ins., which is increased to 7 ft. 2 ins. for the ties which support the

chairs for the conductor rail. The conductor (positive) rail is outside the track, with its head 3 ins. above the track rail and its center 16 ins. from the gage side of the head of the latter. The return (negative) rail is carried by clay insulating chairs on the middle of the ties, and is 1½ ins. above the track rails. These rails have a high electrical conductivity, and their chemical composition is as follows: carbon, 0.05%; manganese, 0.19%; sulphur and phosphorus, each 0.05%; silicon, 0.03%. They were made in Germany, and weigh 85 lbs. per yd. Their joints have four flexible plaited bonds of the American Steel & Wire Co.'s make.

The power station has Babcock & Wilcox water-tube boilers and eight steam turbines of 7,500 HP., each directly connected to a 5,500-KW. generator. The plant is designed for ten of these units. The three-phase alternating current is of 11,000 volts with 33⅓ cycles per second. At the sub-stations the current is converted and reduced to direct-current of 600 volts. The passenger stations have platforms 400 ft. long, built of concrete, and here the iron lining is filled with concrete which is faced with glazed tiles. There are 12 of these stations, equipped with 27 Otis electric elevators having cars for 60 passengers. A spiral stairway is also provided in an 18-ft. shaft, and in the center of the shaft is a 4½-ft. steel pipe connecting with the housing of a ventilator fan 5 ft. 6 ins. diameter, driven at 250 revolutions by a 10-HP. motor. This fan has an exhaust capacity of 20,000 cu. ft. of air per minute. The tunnels are lighted by 16 c. p. lamps 40 ft. apart, while both arc and incandescent lamps are used at the stations.

The cars are entirely of steel, built by the American Car & Foundry Co., being shipped in sections and erected at the car company's works near Manchester, England. The standard trains consist of six cars, each end car being a motor car, with only one motor truck. The ordinary trucks have 30-in. wheels, but the motor trucks have 36-in. wheels, and in order to clear these and the motors the entire underframe is raised 1 ft. 8½ ins. at this end of the car, the floor being 3 ft. 6½ ins. instead of 1 ft. 10 ins. above the rails. On this raised portion are the motorman's compartment and four passenger seats, being reached by three steps. The cars are 50 ft. long over all and 8 ft. 8 ins. wide, while the total height is 9 ft. 5⅝ ins. above the rails. It will be seen that the car is set very low on the trucks, the weight of the body being carried at a level below that of the axles. The distance between truck centers is 33 ft., and the wheelbase is 6 ft. 6 ins. for the motor truck and 5 ft. for the trailing truck. The only wood used is for the interior finish, and this is treated by a fire-proofing process. The cars have low monitor roofs and the sides are curved so as to obtain the greatest possible inside capacity; each car has 20 lamps of 16 c. p. Both transverse and side seats are used, and the seating capacity is 46 passengers in the motor cars and 52 in the non-motor cars. The motor truck has cast-steel frames and has a 200-HP. motor on each axle.

The signaling and interlocking plants are operated on the electro-pneumatic system, with an automatic train-stop device in connection with the block signals. Each block section has an overlap of 400 ft. within the next section, the protecting signal behind a train remaining at the "stop" position until the train has passed 400 ft. beyond it. Switches are operated by pneumatic motors controlled by electric circuits. In each signal cabin is a track diagram of the block sections, the diagram being painted on glass, and each section illuminated when there is no train on the track. Telephone wires are laid through the tunnels, and the motorman has a portable telephone set which can be attached to the wires directly from the cab, thus putting him in prompt communication with the offices in case of emergency. There are no less than eight systems of distribution extending the entire length of the railway, as follows: 1, the high-tension feeder cables to the sub-stations; 2, the collector and return rails for each track; 3, the 220-volt three-phase lighting circuit; 4, the 550-volt circuits for the elevators and arc lamps; 5, the telephone circuits; 6, the signaling circuit through one line of track rails; 7, the negative or return main for the same circuit; 8, the compressed-air pipe for the pneumatic motors operating signals and switches.

The road is owned and operated by the Underground Electric Railways Co., of London, which is also building two other tube lines and has converted the old steam lines of the Metropolitan District Ry. (underground) to electric traction. The total length of these lines will be about 75 miles. Mr. James R. Chapman is Engineer-in-Chief and General Manager of the company.

A BRIEF HISTORY OF THE OVERLAND TELEGRAPH LINE FROM AMERICA TO EUROPE.*

In 1860 the discovery of placer gold on the Fraser river, British Columbia, carried civilization and exploration through to Cariboo and Quesnelmouth, and this being followed in a few years by the explorations for and the construction of the Collins Overland Telegraph Co.'s line, to a great extent opened up the whole district. The trail along the right-of-way of this, our first telegraph line, is even to-day the chief thoroughfare through the district, and has had such a marked influence on this section of the country as to deserve special notice.

The "old Telegraph trail" stands to-day as a monument to one of the boldest, most enterprising, and promptly executed projects, until it was given up, of private origin, that this continent has witnessed, and yet here in British Columbia on the scene of its execution and in the country which has derived the most lasting benefits from its operations, its memory has become so obscured by the short period of 40 years that such data as have been obtainable regarding it have had to be gleaned from brief notices in a dozen books, written by aliens, or gathered from the recollections of the few "old timers" still alive, who happened to know of its history. Among these may be mentioned Mr. R. B. McMicking, now manager of the telephone system of Victoria, who was in 1866 the telegraph operator on the line at Quesnel.

That "nothing succeeds like success" is thus amply verified. This grandly conceived project failed to achieve commercial success, through no fault within itself, and it was buried and forgotten, only to be brought back to memory by a few of those who, having seen its monument, could read the inscription thereon.

In 1864, although land telegraph lines were accomplished facts, subaqueous telegraph cables were still considered impracticable, save for comparatively short lines, and there was no telegraphic communication between Europe and America. The lack of these facilities was the more keenly appreciated as, on both sides of the Atlantic, land telegraph lines were in successful operation, extending, in America, across the continent.

It is true that Cyrus Field's Atlantic cable was even then under construction, but that it was destined to failure was predicted by many of the eminent electricians of that day. That such was the fact is demonstrated by the financing of the "Overland Telegraph" line, now under discussion, by the directors of the Western Union Telegraph Company, then the greatest telegraph corporation in existence.

In 1858 the first Atlantic cable had been attempted, but, although it was laid successfully, it never worked, owing to defective insulation, and it very soon broke.

In 1864 a company, formed largely of the directorate of the Western Union Telegraph Company, undertook to connect America and Europe by telegraph. The original idea was due mainly to Mr. Percy McD. Collins, who had been formerly the U. S. Consular Agent at the mouth of the Amur river in Russia. The scheme contemplated a line of telegraph from San Francisco, up the coast to British Columbia, through that Crown Colony, as it was in those days, to the Yukon; then through Russian America, now Alaska, to Bering sea, which was to be crossed by a comparatively short cable, connecting in Siberia with a line of telegraph to be constructed to the mouth of the Amur river, where it would connect with the Russian Government telegraph line already constructed, and so continue throughout Europe.

For a proper conception of the immensity of this undertaking, it must be remembered that in 1864 the United States had just concluded the Civil War, the Pacific tier of Territories was unsettled and almost unexplored, while British Columbia, the Yukon, Russian America and Siberia were entirely unexplored, save by the fur trading companies, and in British Columbia by the gold miners who had just penetrated as far as Cariboo. All supplies had to come from Europe or from the Atlantic seaboard States, "around the Horn," costing three times what they would to-day, and local labor was very scarce and high-priced.

The necessary charters and rights of way having been obtained from the British and Russian Governments, the command of the expedition for the necessary explorations, etc., was entrusted to Col. Charles S. Bulkley (on leave from the U. S. Army Telegraph Corps), as Engineer-in-Chief. The expedition was organized by Col. Bulkley on a military basis, with Major Wright as Adjutant, and was divided into several sections, to each of which was entrusted a certain portion of the route. The British Columbia section was under the command of Major Frank L. Pope, Assistant Engineer, whose party, including Dr. J. T. Rothrock, and Edward Scoville as Astronomer, left San Francisco for British Columbia on May 17, 1865.

The route adopted in British Columbia was from New Westminster, following up the Fraser river by the Cariboo wagon road as far as Quesnel. At Quesnel the Fraser river was crossed and the line was surveyed in a general northwest direction to Fraser and Francois lakes, and eventually on to Hazleton, on the Skeena river, by way of the "Bulkley valley," so called, as was the river flowing through it, after the Chief of the Expedition, Col. Bulkley, in which valley the horses of the party were wintered during the winter of 1865-6. During 1866 the survey was carried through to Telegraph creek, on the Stikine river. Along the survey line the right-of-way was cut out 50 ft. wide through the timber, and an excellent trail was constructed.

In a written account of the undertaking, kindly supplied by Mr. R. B. McMicking, an active participator in the events, he says:

"With marvelous energy and enterprise the work of construction was commenced in 1865, the line entering British Columbia from the south in 1864, in longitude 122° W., being carried thence to New Westminster, from which point it followed the valley of the Fraser river and the Cariboo wagon road northward to Quesnel, a distance of about 430 miles, which point was reached in 1866. Offices were established along the way, and from Quesnel southward the line was soon opened for commercial business. The enterprise proved a great boon to the early colonists, both by reason of the large expenditure of money necessary in its construction and operation, as well as by the facilities it offered for speedy communication between the widely separated settlements.

"In 1865, also, a branch line was run across the San Juan archipelago to Vancouver Island, connecting Victoria, the capital of British Columbia, with the main line at Swinomish, Wash. This branch was about 74 miles in length, and included five sub-marine cables of a combined length of 10 miles.

"From Quesnel the main line crossed the Fraser river to the westward, and had reached the Naas river, about 400 miles distant from Quesnel, when the second Atlantic cable was successfully laid and operated, July 29, 1866.

"The construction party of about 250 men, on receiving news of the completion of the cable, remained in camp two or three days awaiting developments, and at the end of that time, finding the cable continuing to work well, they set out for civilization, leaving their tools, stores and materials to the tender mercies of the Hudson Bay trapper and the native red man.

"In addition to the work done in British Columbia, 350 miles of wire had been strung in Siberia and 300 in Russian-America (Alaska), and a cable 60 miles long was on the spot ready to be laid across Bering Straits. The original expenditure in the construction of the British Columbia section of the inter-continental line reached the large sum of, roundly, $5,000,000."

When the project was abandoned, the line from New Westminster to Quesnel and Barkerville was continued in operation by the Western Union Telegraph Co. until purchased in 1870 by the British Columbia Government, which, in turn, handed it over to the Dominion Government, upon British Columbia's entering the Confederation in 1871.

On the line from Quesnel northward, things were left as they stood; the line, as far as constructed, was never used and gradually fell; and to-day only one or two poles can be seen standing, while miles of wire have been trodden into the ground by pack animals and can be seen sticking out of the mud at intervals, still perfectly sound and not at all rusted. The greater part of the wire has, however, been taken by the Indians for various uses. With it their houses are tied together; they made it into nails, fish spears, traps, etc., and even constructed most ingenious suspension bridges with it. The "old telegraph trail" has ever since been the main thoroughfare through this northern interior, and from it trails branch off to various districts.

The present Dominion Government telegraph line to the Yukon follows the old line as far as the latter went, utilizing the old right-of-way cutting, but having to replace the poles and wire.

*Extract from Report of the Minister of Mines, British Columbia, for the year ending Dec. 31, 1905.

THE USE OF SCREW SPIKES in Europe has been accompanied by numerous investigations as to their efficiency, and tests have recently been made to determine the torsional power required to screw the spikes into the holes bored in the ties. For this purpose a torsiometer has been invented by Mr. Albert Collet, which is a tee-handled socket wrench so constructed that the torsion exerted is registered by a dial and pointer at the middle of the handle. This has been used in experiments made on the Northern Railway of France.

THE EASTERN RAILWAY OF NEW MEXICO: (ATCHISON, TOPEKA & SANTA FE RAILWAY SYSTEM.)

Extensive improvements in the way of reducing grades and curves have been in progress for some years on all the principal railways from the Missouri and Mississippi rivers to the Pacific Coast (or so-called "transcontinental" railways), and in many cases these improvements involve cut-off or diversion lines of considerable length.

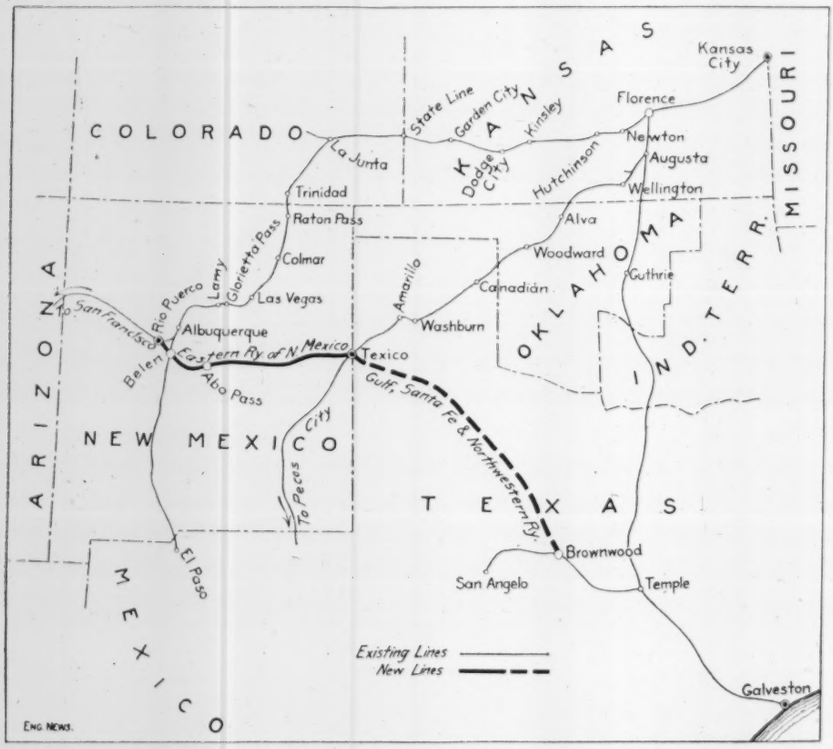


FIG. 1. MAP SHOWING THE RELATION OF THE EASTERN RAILWAY OF NEW MEXICO TO THE TRANSCONTINENTAL ROUTE OF THE ATCHISON, TOPEKA & SANTA FE RY.

The Atchison, Topeka & Santa Fe Railway is now building an important line about 270 miles long, which will complete a cut-off or new route of 760 miles in length, avoiding long mountain divisions with heavy grades and two high summits. This line will open up a new route to the Pacific Coast and to Mexico, and will enable important changes to be made in the Chicago and San Francisco service as well as in transcontinental service generally. As shown by the map, Fig. 1, the present main line to the Pacific Coast runs approximately west from Kansas City to La Junta, Colo., and thence southwest through Albuquerque, to Rio Puerco, N. M., where it again turns west. This line crosses two mountain ranges and includes the noted summits of the Raton Pass and the Glorieta Pass. From Albuquerque there is a line south to El Paso, Tex., for Mexican connections. It will also be seen by the map (which shows only the main lines in question) that there is another line which leaves the Coast line at Florence, Kans. (157.3 miles west of Kansas City), and runs practically southwest to Texico, N. M., whence it turns south to Pecos City, Tex. In considering improvements for the main route it was seen that by connecting these two lines by means of a new link from Texico west to Rio Puerco, the heavy mountain divisions of the older route might be entirely avoided, and a through route provided to the Pacific Coast and Mexico, having much more favorable operating conditions. At Belen, N. M., this link connects with the El Paso line. This new link is about 270 miles long, and is being built under the name of the Eastern Railway of New Mexico. The contractors are Lantry & Sharp, of Kansas City, Mo. For plans and general information as to this line and the station construction (described below) we are indebted to Mr. James Dun, M. Am. Soc. C. E., Chief Engineer of the Atchison, Topeka & Santa Fe Ry. System.

The profiles of the old and new routes between Florence, Kans., and Rio Puerco, N. M. (765 and 760 miles respectively), are shown in Fig. 2, and it will be seen that while the new (southern) route is somewhat more irregular in profile and has heavier grades on the eastern portion, it is much more favorable as compared with the mountain divisions of the older (northern) route. In this connection also, it may be noted that the eastern portion of the new route (between Florence and Texico) is to be materially improved by grade reductions and other work to make it suitable as a part of the main line to the Pacific Coast. The distance between Florence and Rio Puerco is practically the same by both of the alternative routes, the saving by the new line being only five miles, but instead of the two summits of Raton, 7,608 ft., and Glorieta, 7,421 ft., above sea level, there will be the one summit of the Abo Pass, 6,492 ft. above seal level. The maximum grades on the mountain divisions of the new line are 0.6% westbound and 1.25% eastbound, as compared with 3.6% in the Raton Pass. There are only a few miles of the 1.25% grade, however; this is in the Abo canyon, a[re] only place where such a grade occurs [be]tween that point and Chicago. The new line [is] much easier in regard to curvature, and [the] maximum curves are 2°, except that in the [Pass] there are several curves of 4°. The ne[w] being built with a roadbed 20 ft. wide [with] embankments and 28 ft. in cuts. It is [la]id with 85-lb. rails, while the existing line betwe[en] Florence and Texico is to be relaid with simi[lar] rails. Passing sidings ¾-mile long will be pro[vided] at intervals of seven miles. All stations w[ill be] of concrete construction and are described b[elow].

It is expected that when the new [line] is opened the time of through passenger tr[ains] between Chicago and San Francisco may [be] reduced five or six hours, but the greater [im]portance of the line will be in affording a [more] favorable and economical route for freight [traf]fic. The freight trains can be made heavier and run in quicker time, and the cost of operation will be correspondingly less. The same will apply to the Kansas City and El Paso route to Mexico. Another important feature of the new line is that in connection with the Gulf, Santa Fe & Northwestern Ry., now being built by the Atchison, Topeka & Santa Fe Ry. from Texico southeast to Brownwood, Tex. (310 miles), a new and direct route of about 1,820 miles in length will be opened between Galveston and San Francisco. This is also shown on the map, Fig. 1.

CONCRETE RAILWAY STATIONS.

One of the interesting features of the Eastern Railway of New Mexico is the use of concrete for the railway stations, this type of construction being adopted to ensure safety from fire and a permanent character of building, although the first cost will be about 40% greater than that for similar buildings of frame construction. The standard stations have buildings 65 × 24 ft. in plan, and there are two or three larger stations with accommodations for division offices, etc. These buildings were designed by Mr. Myron H. Church, architect, of Chicago, and the contractors are Nelson & McLeod, of Chicago. Some idea of the character of the country may be gathered from the fact that in the contract for building the stations the railway company agrees to furnish free all water required, by means of tank cars.

The elevations and plans of one of the standard stations are shown in Figs. 3 and 4, while Fig. 5 shows some of the details of wall and roof construction. In Fig. 6 are elevations and plans of the larger stations with terminal offices. In this design there are offices on the second floor for the division officers, and there are no living rooms for the operator or station agent, as in the standard stations.

The following particulars of the construction refer to all the stations. All exterior walls, foundations, piers, chimney and interior partitions on the first floor are of Portland cement concrete, mixed in proportions of 1 part cement to 3 of sand and 5 of crushed stone. The stone is of hard, clean limestone or hard cobble stones

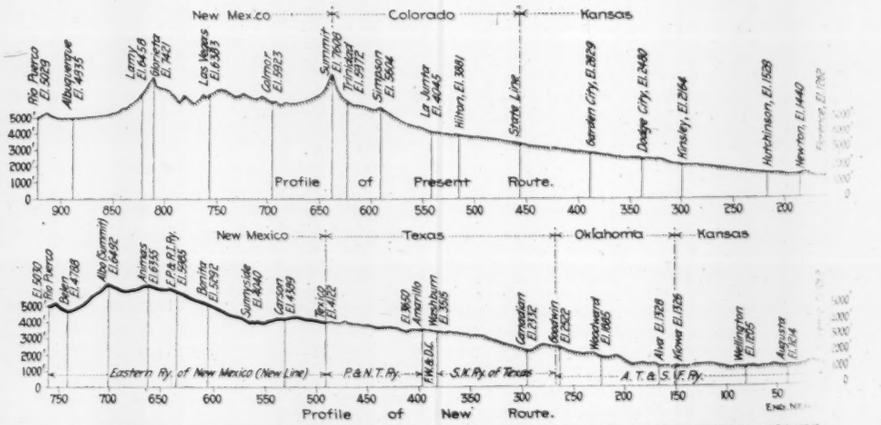


FIG. 2. PROFILES OF PRESENT AND NEW LINES IN THE TRANSCONTINENTAL ROUTE OF THE ATCHISON, TOPEKA & SANTA FE RY.

broken t[illegible]ass through a 1½-in. ring; all product from th[illegible]usher is used except that which passes through [illegible]screen of ¼-in. mesh. It is specified that the [illegible]ater used must be free from acids or strong a[illegible]lies. In proportioning the concrete the cement [illegible]assumed to weight 100 lbs. per cu. ft., and the corresponding volume of a barrel (four bags) at 3.8 cu. ft. will give quantities by volume of one barrel of packed cement to 11.4 cu. ft. of loose sand, and 19 cu. ft. of loose stone. The cement may be measured in the original barrel or bags; the stone and sand must be measured in boxes of proper size, not in wheelbarrows. The forms must be of dressed lumber with the dressed face on the inside, and wetted before the concrete is laid; they must be left in place for not less than 48 hours after the placing of the concrete.

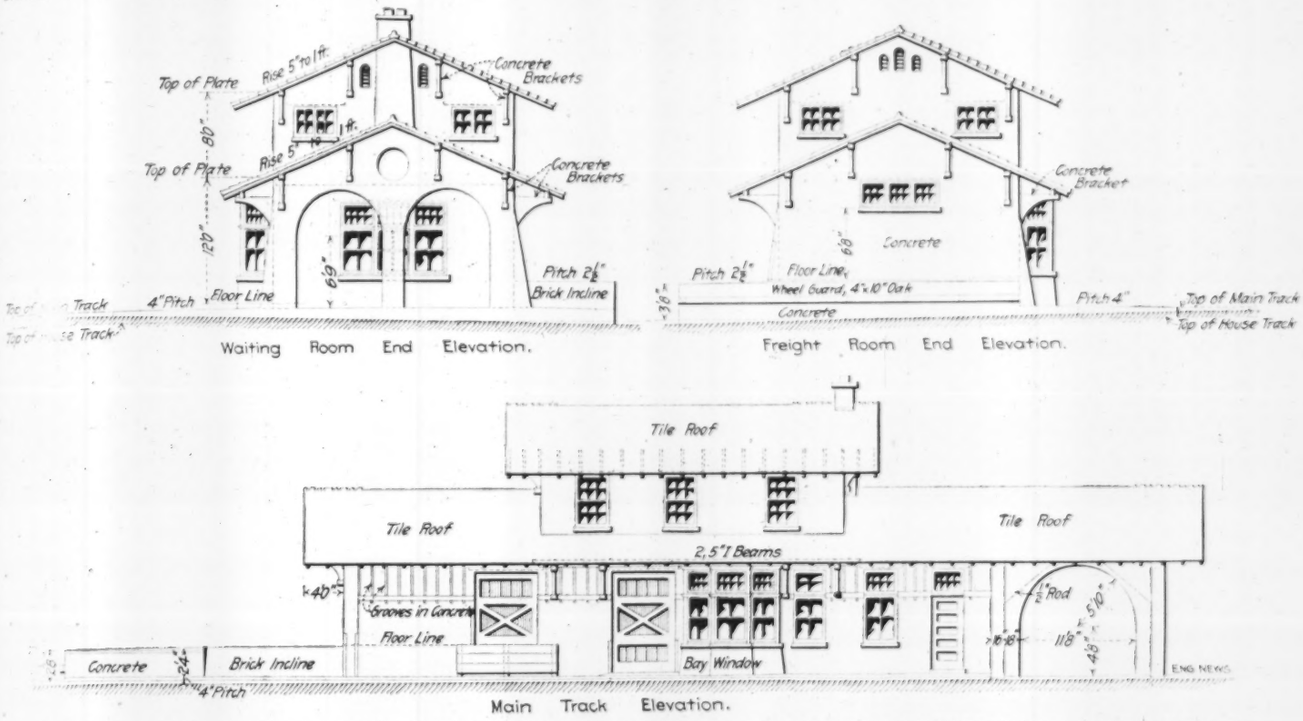


FIG. 3. ELEVATIONS OF STANDARD CONCRETE STATIONS FOR THE EASTERN RAILWAY OF NEW MEXICO (A., T. & S. F. RY. SYSTEM).
J. Dun, M. Am. Soc. C. E., Chief Engineer. Myron S. Church, Chicago, Architect.

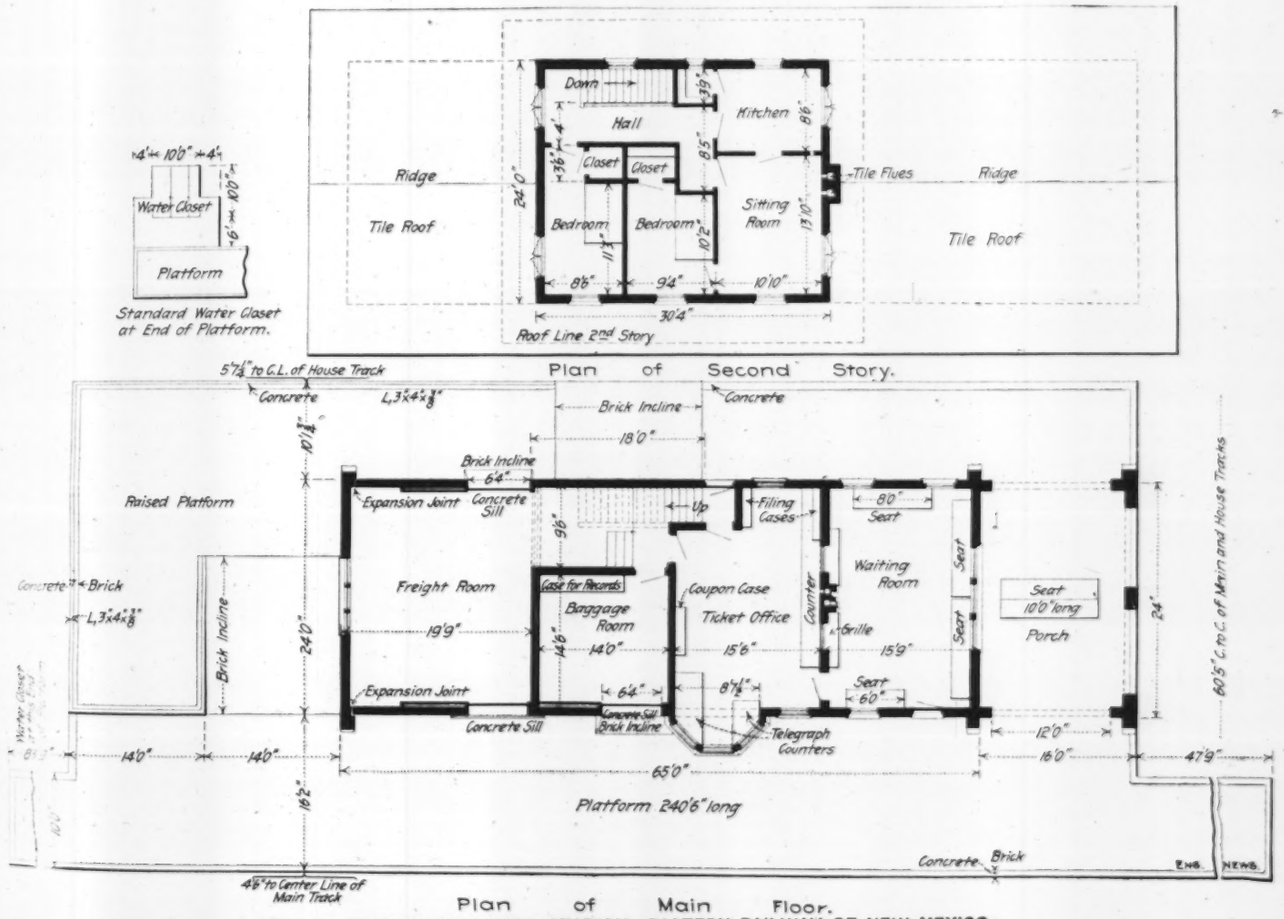


FIG. 4. PLAN OF STANDARD STATION: EASTERN RAILWAY OF NEW MEXICO.

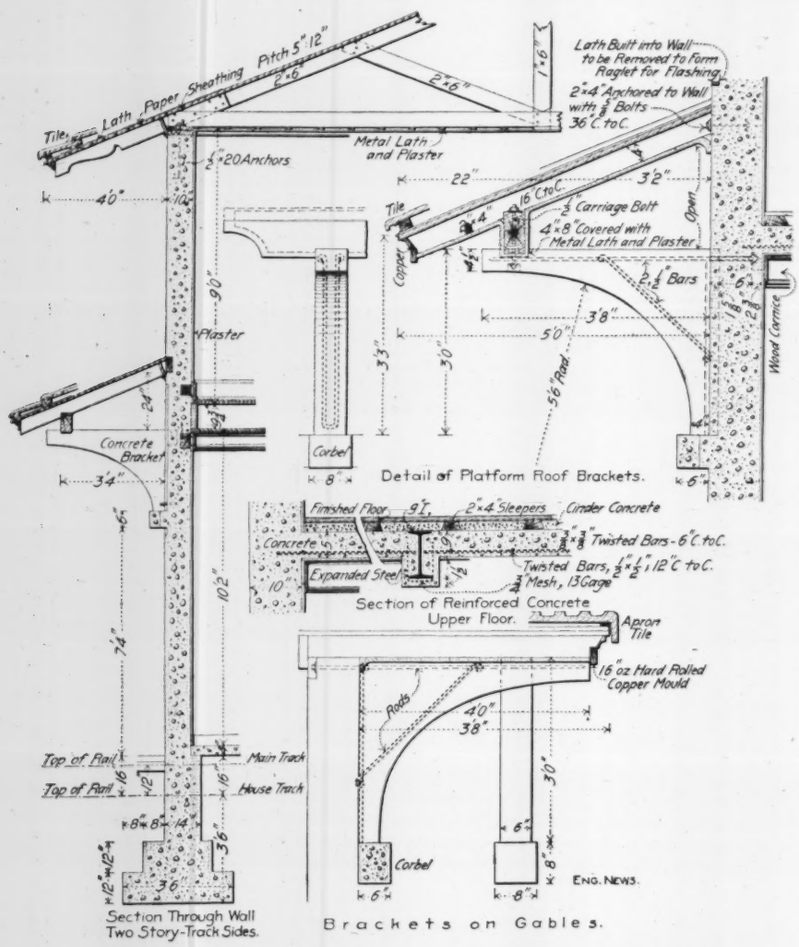


FIG. 5. DETAILS OF CONSTRUCTION OF CONCRETE STATIONS.

The exterior surface of walls is wetted and given a pebble dash finish, using clean gravel screened by a screen of ½-in. mesh. The upper part of the walls will also be broken by vertical score marks or grooves, as shown. All window and door sills, corbels and exterior brackets for roof are cast in molds and set in place as the work progresses; the concrete for these is composed of 1 part Portland cement, 1 part sand and 3 parts of ½-in. gravel. The exposed portions of the sills have a smooth finish, and the sills for baggage and freight room doors are 8 ins. thick. The jambs for these doors are protected by steel angles 4 × 4 ins. All blocking for nailing interior finish, and all anchors, bolts, etc., are built into the concrete. Over some of the openings the concrete is reinforced by steel rods at least 16 ins. longer than the width of opening, and turned up at the ends; two 5-in. I-beams are also set over the bay in the freight room, to support the second story wall. The chimney is of concrete, with pebble-dash finish and smooth cap, and has a lining of 8½ × 8½ tile, which projects 9 ins. above the concrete cap. The floors are of concrete, 4 ins. thick in the waiting room and ticket office, and 5½ ins. in the baggage and freight rooms; this includes the ½-in. top dressing. The rough concrete is a 1-3-5 mixture, using stone of ½ in. to 1 in. in size; the ½-in. top dressing is of sand and cement, 1 to 1, spread on before the rough concrete has had time to set. The floors are troweled to a finish, and in the baggage and freight rooms are blocked off with joints cut clear through. All concrete work is guaranteed for five years.

The upper floor was originally intended to be of timber joists and flooring, but this has been abandoned in favor of 5-in. concrete floors (1-2-4 mixture) with steel I-beams; the floor is reinforced by steel bars, and ¾-in. expanded metal is wrapped around the beams. The roof has a plank sheathing covered with a layer of asphalted felt, and upon this is the roofing of Ludowici red tiles. The interior finish is of plaster on expanded metal lathing; the plaster is given two coats of paint, and the wood trim, etc., is varnished. For the exterior, the sashes, door and window frames, etc., are painted white, while the doors are dark green.

The station is surrounded by a platform, and on the main track side this is extended to a total length of 240 ft. 6 ins. The construction is shown in Fig. 7. A portion of the platform, at the rear and end of the freight room, is raised to a height of about 3 ft. 2 ins., for convenience in loading and unloading wagons. Inclines connect this with the main platform level. The platform is of brick with a curbing of concrete; this latter is a 1-3-5 mixture, and for exposed surfaces the forms are plastered with a 1 to 1 mixture 1 in. thick. On top of the cinder filling is a 3-in. bed of sand, wetted, graded and tamped; on this is a course of paving brick, laid flat, with 1-16-in. to ⅛-in. joints; covered with sand which is well worked into the joints and then swept off. The surface of the platform has a pitch of ¼-in to the foot towards the track.

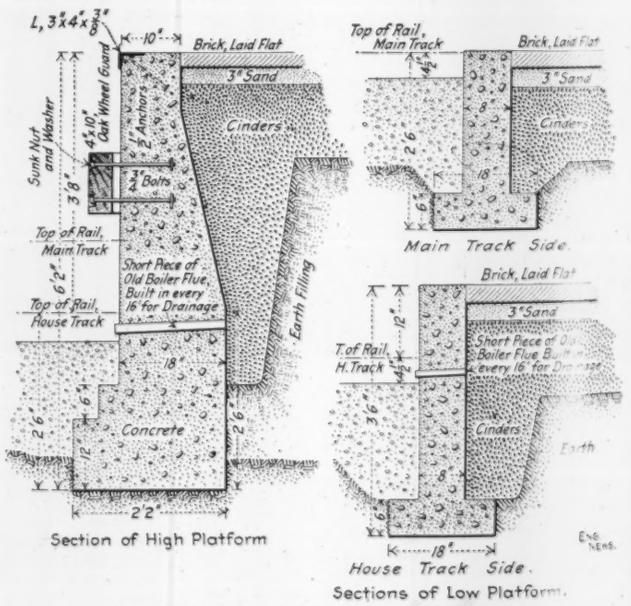


FIG. 7. DETAILS OF STATION PLATFORMS.

PEAT AS FUEL IN THE UNITED STATES IN 1905.*

By Marius R. Campbell.†

The following companies are reported as interested in the development of the peat industry, but many of them have not as yet installed a plant, and those that have completed their installation are not beyond the experimental stage: Orlando Water & Light Co., Orlando, Fla.; Illinois Peat Fuel Co., Chicago, Ill.; Indiana Peat Fuel Co., Tyner, Ind.; Peat Gas & Coal Co., Portland, Me.; Boston Fuel Co., Boston, Mass.; American Peat & Fuel Co., Capac, Mich.; Capital Peat Fuel Co., Detroit, Mich.; Michigan Peat Co., Chelsea, Mich.; Michigan Peat & Marl Co., Grand Rapids, Mich.; Van Buren Peat Co., Gobleville, Mich.; Wolverine Peat Co., Vicksburg, Mich.; Mankato Peat Fuel Co., Mankato, Minn.; Northern Peat Co., Minneapolis, Minn.; Willmar Peat Co., Willmar, Minn.; American Peat Fuel Co., Lincoln Park, N. J.; Amalgamated Peat Fuel Co., 80 William St., New York, N. Y.; Peat Koal Co., New Rochelle, N. Y.; Martine Peat, Light & Power Co., Fond du Lac, Wis.; Western Peat Co., Marshall, Wis.

The production of these experimental plants for 1905 is estimated at 2,000 tons. The work of the Orlando Water & Light Co., of Orlando, Fla., may perhaps be considered typical. There is a popular impression that peat bogs are largely if not wholly confined to northern countries, but this is not correct, since Florida has some of the finest deposits of peat in this country. The Orlando Co. is working on a deposit filling a small lake basin. The company has installed a Leavitt machine with a belt conveyor for transporting the peat to the mill, where it is disintegrated and molded into bricks without pressure. The bricks are then laid out, and in the hot Florida sun soon lose a large percentage of their moisture. As the peat comes from the bog it carries about 85% of water, but in a few days after the bricks have been manufactured this is reduced to 30% and finally to about 15% without artificial drying. When the bricks have reached this stage they have shrunk to about one-half their original dimensions, and then they may be stacked out in the weather without reabsorbing an appreciable amount of water.

The business is hampered by the excessive rains which prevail in Florida during the wet season from June to November, and some means of artificial drying or protection must be resorted to before the works can be kept in continuous operation.

Although the plant has not passed the experimental stage, several hundred tons of the machine peat have been produced and used under the boilers of the electric light plant. It is confidently believed by the owners that peat fuel produced in this way can successfully stand in competition with hard-pine wood at $3 per cord and Alabama coal at $7 per ton.

The most interesting and perhaps the most valuable experimental work that has been done during the year [1905] is the practical tests of machine peat as a producer-gas fuel. These experiments were carried on at the United States Geological Survey coal-testing plant at St. Louis on one carload of peat from Massachusetts and another from Florida. The former consisted of part raw and part machine peat, and both kinds were tried in the producer, but the quantity of peat was not sufficient for

*Condensed from advance pages of Mineral Resources of the United States, Calendar Year 1905.

†U. S. Geological Survey, Washington, D. C.

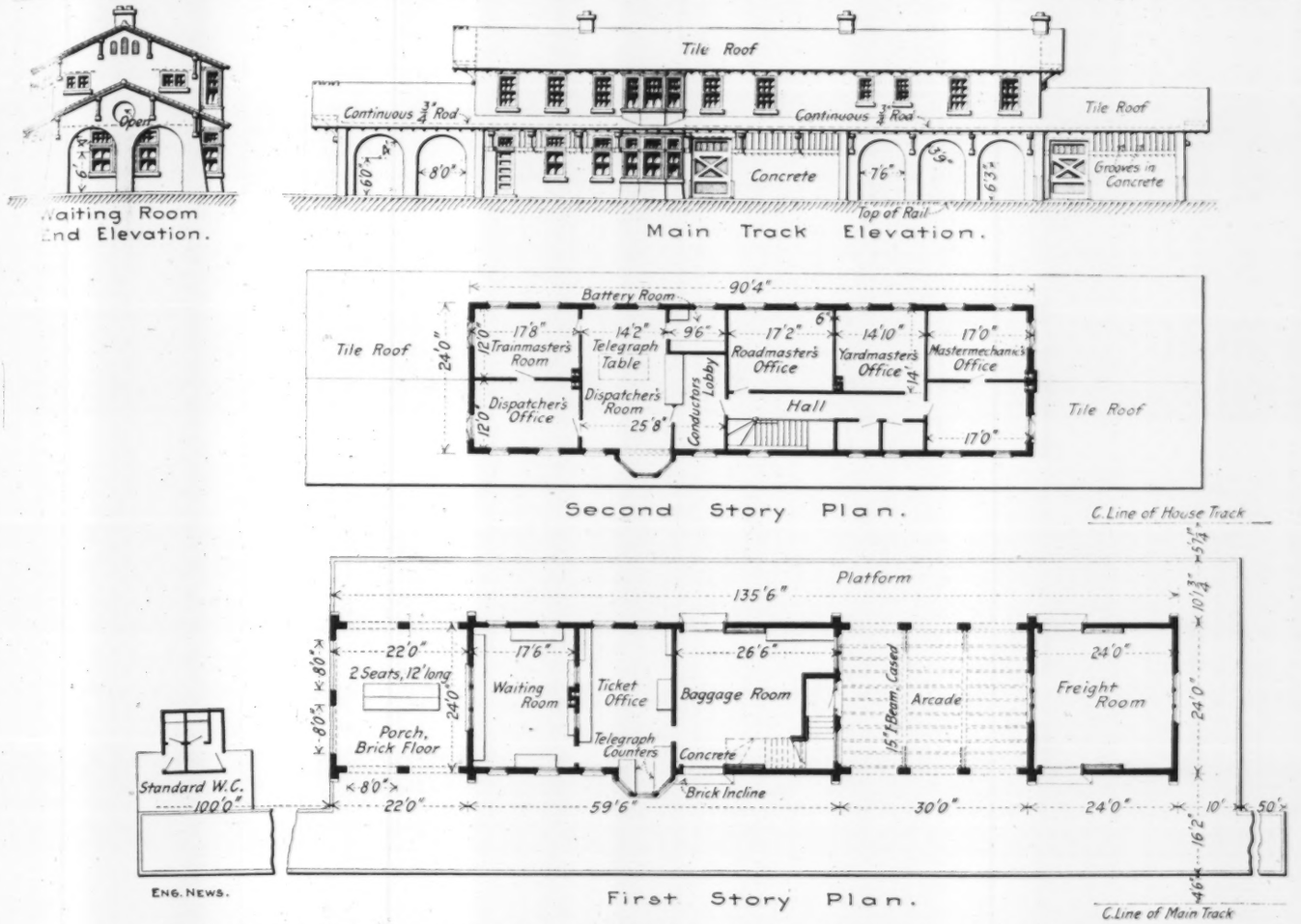


FIG. 6. ELEVATIONS AND PLANS OF STATIONS AT TERMINAL POINTS: EASTERN RAILWAY OF NEW MEXICO.

a thorough test. Although there were many large fragments of wood in the peat, that part which was machined proved to be an excellent producer fuel, making a gas of high calorific power and of even composition. This test was regarded as quite satisfactory; but when raw peat was tried the work of the producer was not satisfactory, for the peat, although dry, burned only where it came in contact with the shell of the producer, and thus the quality of the gas was spoiled.

The second trial was made on a car of machine peat from Orlando, Fla. This gave excellent results, regarding both calorific power and regularity of composition of the gas, also ease of firing. The results of this test are embodied in the following table:

Producer-Gas Test of Florida Machine Peat.

	Peat as fired.	Dry peat.	Combustible.
Pounds consumed in producer.			
Per electrical horse-power:			
Available for outside purposes.	2.98	2.35	2.20
Developed at switchboard.	2.85	2.25	2.11
Per brake horse-power:			
Available for outside purposes.	2.53	2.00	1.87
Developed at engine.	2.43	1.92	1.79
Equivalent pounds used by producer plant.			
Per electrical horse-power:			
Available for outside purposes.	3.16	2.50	2.33
Developed at switchboard.	3.03	2.39	2.24
Per brake horse-power:			
Available for outside purposes.	2.69	2.12	1.98
Developed at engine.	2.57	2.03	1.90
Average electrical horse-power			205.0
Average B. T. U. per cubic foot of gas			175.2
Total peat fired, lbs.			29,250

Analyses Showing Average Composition. Peat.		Gas by volume.	
Moisture	21.00	Carbon dioxide (CO_2)	12.4
Volatile matter	22.11	Carbon monoxide (CO)	21.0
Fixed carbon	51.72	Hydrogen (H_2)	18.5
Ash	5.17	Methane (CH_4)	2.2
	100.00	Nitrogen (N_2)	45.5
		Ethylene (C_2H_4)	.4
Sulphur	.45		100.0

In starting the producer-gas test the entire fuel bed was built up of the Florida peat, and the usual preliminary run was conducted before the official test was begun. The official test lasted 50 hours, and during the entire period no difficulties were experienced either in maintaining the load or in handling the fuel bed.

Only a small quantity of peat remained after the producer-gas test was made, and on this a steaming test was made which lasted 4.07 hours. This was too short to yield satisfactory results, but owing to the scarcity of such tests the results may be of value. They are as follows:

Steaming test on machine peat from Orlando, Fla.

Heating value of peat, B. T. U. per lb. of dry peat.	10,082
Duration of test, hours	4.07
Kind of grate	Plain.
Force of draft:	
Under stack damper, ins. water	0.69
Above fire, ins. water	.13
Furnace temperature (by Vanner optical pyrometer), °F	2,457
Dry peat, used per sq. ft. of grate surface per hour., lbs.	33.49
Equivalent water evaporated per sq. ft. of water-heating surface per hour., lbs.	4.04
Per cent. of rated horse-power of boiler developed.	113.2
Water apparently evaporated per lb. of coal as fired, lbs.	4.27
Water evaporated from and at 212°F.:	
Per lb. of peat as fired, lbs.	5.00
Per lb. of dry peat, lbs.	6.04
Per lb. of combustible, lbs.	6.63
Efficiency of boiler, including grate, per cent.	577.85
Peat as fired:	
Per I. HP. hr., lbs.	5.66
Per E. HP. hr., lbs.	6.98
Dry peat:	
Per I. HP. hr., lbs.	4.68
Per E. HP. hr., lbs.	5.78

Analyses of Peat Used. Proximate of peat as fired.		Ultimate of dry peat.	
Moisture	17.21	Carbon	57.77
Volatile matter	24.85	Hydrogen	5.18
Fixed carbon	51.01	Oxygen	25.20
Ash	6.93	Nitrogen	2.89
	100.00	Sulphur	.59
Sulphur	.49	Ash	8.37
			100.00

As is seen by reference to the figures, the results secured from this fuel when used under the boiler are exceedingly gratifying. Comparing the dry peat per electrical horse-power per hour required by the two types of plants, it will be noticed that the steam plant used 5.78 lbs., or 2.4 times as much as the producer-gas plant, which required only 2.39 lbs.

These results show that peat can be much more successfully used for the generation of power in a producer than in a furnace under a steam boiler. Moreover, they show that when used in this way peat may become a successful competitor of coal, even where the latter can be easily obtained.

The possibilities which these experiments seem to open are great, and they may be of infinite value to such States as Florida, Massachusetts, Maine, Minnesota, and Wisconsin, which have little or no coal within their boundaries, but have large deposits of peat that are easily accessible to the commercial centers.

THE ELEVATED ELECTRIC RAILWAY at the Milan Exhibition (Italy) is a double-track timber trestle structure, with steel spans over streets and railway lines. It connects the main part of the exhibition with the park in which certain classes of exhibits are arranged, and is 4,800 ft. long, with no intermediate stations. It has curves of 300 ft. radius and a maximum grade of 3%. Each bent has four posts, and the rails are 16.4 ft. above the ground, while the span wires for the trolley wire are 19 ft. above the rails; the tracks are 9.15 ft. c. to c. It is operated on the Finzi single-phase series motor system, with a frequency of only 15 cycles. The power plant consists of a 2,000-volt, single-phase, six-pole, alternating-current generator driven by a 3,600-volt three-phase motor; there is also a smaller generator driven by a gas engine. Each train consists of four cars, 32 ft. long, each mounted on two axles, with a wheelbase of 13 ft.; large end platforms are provided so that while each car has seats for only 24 persons it can carry 60 passengers. One of the intermediate cars has two Siemens bow contacts in place of wheel trolleys. Each of the end cars has two motors and each intermediate car has a single motor, making six in all. The motors are started by voltage control, through a transformer. In starting, half the normal voltage is used, and each successive step of the controller adds 30 volts, thus bringing up the voltage from 180 to 360 volts; for the three motors in series this means an average of 120 volts per motor. The controller is so arranged as to permit the use of either direct or alternating current. The trains run on a 3-minute headway, and the maximum speed is 20 miles an hour.

STATE CENSUSES were taken in Florida, Iowa, Kansas, Massachusetts, Minnesota, New Jersey, New York, North Dakota, Oregon, Rhode Island, South Dakota, Wisconsin and Wyoming in 1905, and in Michigan in 1904.

LARGE DERRICKS FOR THE ERECTION OF STEEL BUILDINGS.

In the erection of the steel framework of modern high office buildings, use is generally made of stiff-leg or guyed derricks of steel or timber construction, and in most cases these can place the material only for two or three floors and have then to be dismantled and re-erected on a higher floor. In some special cases, however, where the new building is an extension of an older one, the

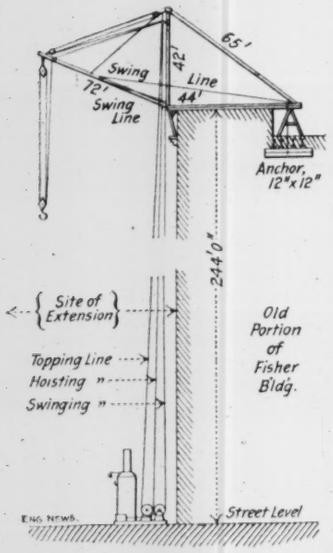


Fig. 1. Position of Derrick on the Fisher Building, Chicago, for Erecting an Extension.

derrick is erected on the roof of the older portion and does not require to be moved during the entire progress of the work. This latter method has recently been adopted in two cases in Chicago; the Adams St. extension of the Marquette Building and the Dearborn St. extension of the Fisher Building. The original construction of both these buildings was described in our issue of Oct. 17, 1895. The Fisher Building, at the corner of Dearborn and Van Buren Sts., is now having a 60-ft. extension built on the north side, and for information and drawings of the methods used in erecting the steel frame of the extension we are indebted to the contractors, the Thompson-Starrett Co., Railway Exchange Building, Chicago. The general arrangement is shown in Fig. 1, while Fig. 2 shows the derrick more in detail, and Fig. 3 is a view taken during the progress of the work. The derrick was built by the American Hoist & Derrick Co., of St. Paul, Minn.

The first thing to be done was to erect the 10-ton derrick, which was mounted on the top of a house or superstructure extending above the level of the main roof of the Fisher Building and enclosing the elevator machinery, etc. The foot of the derrick mast was 244 ft. above the street level. A triangular framework of 12 × 12-in. sill timbers was laid on top of this house, with its apex projecting just beyond the north wall, and supported by inclined struts running beneath the apex to the cornice at the level of the main roof. The rear ends of the sills projected over the main roof and were supported by timber A-frames. The sills were anchored to the roof beams by means of steel cables at five points: two of these were at the outer ends of the stiff legs, where cables were dropped vertically to the main roof and made fast to timbers held against the under side of the roof beams; at D, on the false sills C, C was a third anchor; two other anchor cables extended diagonally from the points A and B at the ends of the sills to anchorages at E and F in the roof. These last tended to take up the stresses due to the slewing effect of swinging the boom and also the stresses due to wind. An extra timber A B, 12 × 12 ins., 72 ft. long, was laid across the ends of the sills and lashed to them in order to take up and distribute the vibration in the derrick and also to serve as an additional anchorage. At the apex of the sill frame was the 42-ft. mast, far enough beyond the edge of the roof to allow the lines to pass down the end of the building. The head of the mast was carried by the two 65-ft. stiff-legs. The boom was 72 ft. long, having a maximum reach of 69 ft., at an angle of about 70° with the mast. All these timbers were 12 × 12 ins. The swing and reach of the boom covered the entire area of the extension.

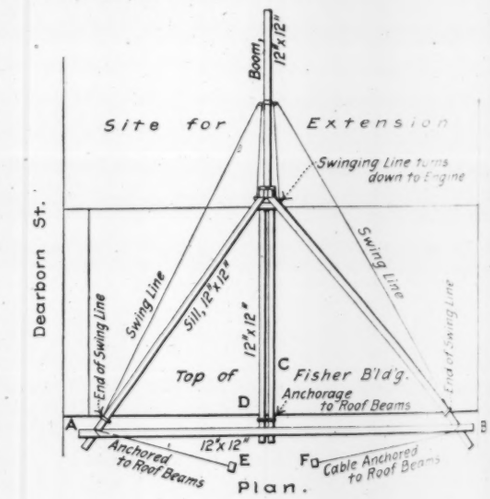
An interesting feature of the work was the way in which all movements of the derrick were controlled from a 20-HP. Lidgerwood double-drum double-spool engine on the first-floor level. The two swinging lines were 1⅛-in. manila ropes, having their ends attached to the sills; they passed through blocks at a point slightly beyond the middle of the boom, thence to other blocks at the foot of the mast, and down to the spools of the hoisting engine. The topping lift acted from two points on the boom; one at the outer end and the other at about the middle of the boom, as shown in the cuts; its attachment to the middle of the boom tended to prevent vibration and also strengthened the boom. This line passed through a sheave at the top of the mast and down to the engine. The fall or hoisting lines were rigged in the usual manner. A signal wire was carried up to the working floor (at two-story intervals, as described below), and operated by a man taking verbal or sign signals from the erecting gang.

It may be of interest to note that the Fisher Building was originally built on pile clusters for the foundations, but on account of irregular settlement deep foundations of the caisson type have been put under it, and similar foundations are used for the new extension. In the extension of the Marquette Building, the beams of the first panel of the new portion were attached to the end columns of the old portion, but in the Fisher Building the extension is entirely self-contained, having its own columns and girders against those of the old portion of the structure. One reason for this is that the older portion leans slightly to the east and it would have been difficult to make satisfactory connections. In its height of over 240 ft. the inclination is such that towards the top the new (vertical) columns project several inches beyond the face of the wall of the older building. The walls are of tile construction, and as the erection progressed, the outer sheathing of tile of the old north wall was removed, as well as the tile covering and brick filling of the columns and girders, in order to make room for the new work.

The erection was done two stories at a time. The columns (in two-story lengths) were set in place, and the beams (or plate girders at the north and south ends) fitted between them, after which the floor beams were set. All this work was temporarily bolted, men following the erecting gang and putting in enough additional bolts to make the work secure until the riveting gangs reached it. As soon as the beams of the second floor of each stage of work were in place, planks were laid and the steel work for the next two-story stage was hoisted from the street by the derrick and deposited on this floor, ready for erection. The riveting was done by pneumatic hammers. Following the riveters came the painters, and close behind them came the flooring gangs laying the hollow tile floors. These were in turn followed by the gang which erected the exterior terra-cotta tile walls. The work was done very systematically and rapidly, and before the steel framework had reached the top several floors were in and part of the walls were in place. Small platform elevators handled the tiles, cement, etc., while the men erecting the wall tiling worked on platforms suspended by cables from beams projecting from the upper stories.

Reference has been made to the use of derricks in new buildings where the derrick [illegible] to be carried by the new framework and [illegible] up as the erection progresses. This pla[illegible] followed in the first part of the structure [illegible] Commerical National Bank Building on [illegible] St., adjoining the Marquette Building. [illegible] case two very large steel stiff-leg derricks [illegible] used, the masts and booms being of box-[illegible] construction, while the stiff-legs were of t[illegible]. The mast was 39 ft. high, and the boom [illegible] ft. 9 ins. long; the latter could be swung ho[illegible] tally so as to give a reach for its full l[illegible]. Each derrick had a hoisting capacity of 20[illegible] and was operated by a 32-HP. engine. N[illegible] iron was used in their construction, the [illegible] necks and base plates being of forged [illegible]. They were designed by Mr. Charles L. Osten[illegible], of the Oscar Daniels Co., for the Lanqui[illegible] & Ilisley Co., which had the contract for [illegible] building. This building is of considerable [illegible], but a deep narrow part was first erected [illegible] some of the offices at once occupied. As soo[illegible] as this was completed, derricks were installed [illegible] the top to handle the steel of the remainde[illegible] of the building. For the portion beyond the re[illegible] of these derricks smaller derricks were set up [illegible] the work and moved and re-erected as the w[illegible] progressed.

In the erection of the steel work for the [illegible] County Building, Chicago, guyed derricks [illegible] used, having the head of the mast supported [illegible] a number of radial guy ropes. In these derri[illegible] the mast is 80 ft. high, and the boom ha[illegible] a length and reach of 70 ft.; they are of 25 [illegible] hoisting capacity and the lines are handled [illegible] 30-HP. engines. The derricks were built by [illegible] William Grace Co., of Chicago, which has [illegible] contract for the construction of the buildi[illegible], and the company states that it believes they [illegible] more easily handled and more economical than stiff-leg derricks.



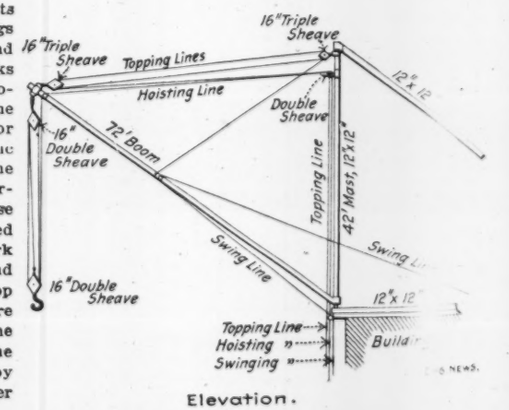


FIG. 2. STIFF-LEG DERRICK.

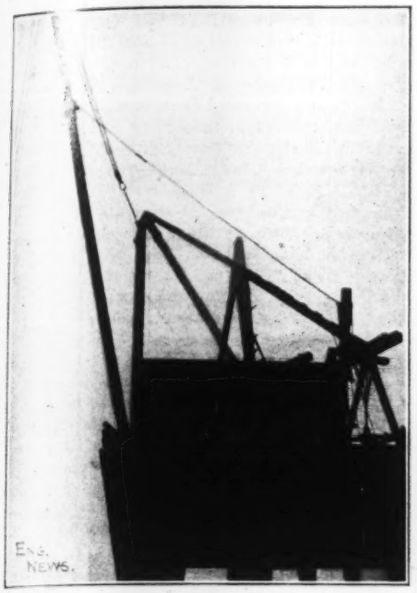


Fig. 3. Derrick on Top of Fisher Building, Chicago.

THE NOMENCLATURE OF ARTESIAN WELLS.

The nomenclature of artesian wells is interestingly discussed by Mr. Myron L. Fuller, Geologist in Charge of Underground Water Supplies, U. S. Geological Survey (Water-Supply and Irrigation Paper No. 160). As many of our readers know, there is much looseness in the use of the word "artesian," and great variation of its use in different parts of the country. A canvass of the leading geologists of the country engaged in hydraulic studies showed that 8 were in favor of dropping the term "artesian" entirely, 12 would apply it to flowing wells, only, 25 would extend its use to all wells in which water rises above the level at which it was found in sinking a well, and 2 would go so far as to use the term to designate any deep well. It should be stated, however, that some of the opinions were modified after there had been correspondence on the subject. In concluding his discussion of nomenclature, Mr. Fuller submits the following:

To secure the best results it is believed that certain principles should be assumed as a guide in the selection of terms. These are briefly outlined as follows:

(1) The question of depth should not enter into the probable nomenclature.

(2) Definitions should, if possible, be based on principle and not on accident.

(3) The terms should be scientific and should be capable of accurate definition.

(4) Provision should be made for terms for the hydrostatic basin and principle.

(5) The terms should meet the needs of the greatest possible number of workers.

PROPOSED DEFINITIONS.

Along the line sketched in the preceding pages, the replies received from other geologists being considered, the terms to be used were thoroughly discussed by the members of the division of hydrology at the Survey, as a result of which the following definitions were agreed on with practical unanimity as the most expedient at the present time:

ARTESIAN PRINCIPLE.—The artesian principle, which may be considered as identical with what is often known as the hydrostatic principle, is defined as the principle in virtue of which water confined in the materials of the earth's crust tends to rise to the level of the water surface at the highest point from which pressure is transmitted. Gas as an agent in causing the water to rise is expressly excluded from the definition.

ARTESIAN PRESSURE.—Artesian pressure is defined as the pressure exhibited by water confined in the earth's crust at a level lower than its static head.

ARTESIAN WATER.—Artesian water is defined as that portion of the underground water which is under artesian pressure and will rise if encountered by a well or other passage affording an outlet.

ARTESIAN SYSTEM.—An artesian system is any combination of geologic structures, such as basins, planes, joints, faults, etc., in which waters are confined under artesian pressure.

ARTESIAN BASINS.—An artesian basin is defined as a basin of porous bedded rock in which, as a result of the synclinal structure, the water is confined under artesian pressure.

ARTESIAN SLOPE.—An artesian slope is defined as a monoclinal slope of bedded rocks in which water is confined beneath relatively impervious covers owing to the obstruction to its downward passage by the pinching out of the porous beds, by their change from a pervious to an impervious character, by internal friction, or by dykes or other obstructions.

ARTESIAN AREA.—An artesian area is an area underlain by water under artesian pressure.

ARTESIAN WELL.—An artesian well is any well in which the water rises under artesian pressure when encountered.

THE BITUMEN SPRINGS OF ANTIQUITY.

By Edgar James Banks.*

On the right shore of the Euphrates, three days above the ruins of ancient Babylon, is the equally ancient city which is now called Hit, but which in ages past has possessed a variety of names. To the Egyptians it was known as Ist; to the Greeks as Is; to the Babylonians as Ihi, and to the Hebrews as Ahava. The bitumen springs which surround the town have made it a place of importance since the greatest antiquity, and again when modern civilization reaches Mesopotamia, they will be a source of great revenue to the country. The pitch has for many centuries served as mortar for laying bricks and for smearing the ark-like boats which ply the Tigris and Euphrates.

The modern town of Hit consists of a few hundred mud or stone huts, perched upon a high mound formed by the ruins of earlier buildings. About the low plain in which the springs are situated are sandy spots; other parts of it are covered with the water from the neighboring salt springs, or with the salt which has been evaporated from it, and here and there, among the patches of sand and the white crystals of salt, are great black spots which mark the sites of a bitumen spring. Two of them are but a few feet apart, and one of them ejects a slowly oozing stream of the black pitch, excepting occasionally, especially after a rain, when a small amount of cold water comes forth with it. The other spring constantly sends out a large stream of steaming warm water, and great pieces of bitumen, which, choking up the opening, squirm and wiggle their way through with a gurgling sound, until finally releasing themselves, rise to the surface.

To the numerous small springs surrounding the town little attention is given, for the one large spring produces a supply far in excess of the demand. This, like nearly every object of value in Turkey, is the property of the Government, but the only means of deriving a revenue from it is to lease it for 80 cents a day to anyone who may desire its products.

The modern use of bitumen does not differ greatly from that of the earliest times. While visiting the springs in 1903, a large lime kiln stood upon the ridge which had formed about the water, and as the great chunks of bitumen came gurgling through the orifice they were seized by an Arab boy, loaded into two large baskets, which were balanced across the back of a donkey, and carried to the kiln, where they were used as fuel for burning lime. Thus was obtained a mortar of scarcely a tithe of the value of the pitch which was consumed to produce it.

The bitumen, if left in its natural state, retains its tar-like softness, and is of but little practical use. It is only when boiled for a considerable time that it may be employed for the various purposes which it serves. In the modern houses at Hit, when built of stone, mud and not lime or bitumen is the mortar. The narrow streets, which are practically the cess-pools of the town, are unpaved. Only occasionally the flat roof of a house is covered with a layer of bitumen, to shed the rains of winter, yet the pitch is used for various less important purposes. Every Mesopotamian Arab is provided with a club upon one end of which is a large knob of bitumen; frequently it is his only weapon. The brick masons employ a small wicker basket smeared over with bitumen for carrying the mud and mortar used in their constructions. Pots and various other household utensils are of pure bitumen, and the same black pitch is the only cement with which they repair broken objects of all descriptions. However, its principal use is in the manufacture of the river craft, and because of its proximity to the springs, Hit has always been a ship-building town. Most of the smaller boats are constructed of wattled twigs, sometimes woven into circular coracles, or canoes, or scow-like, flat-bottom structures, and then thickly smeared without, and sometimes within, with the pitch. It is the incessant noise from the ship-building industry, the clatter of the large, revolving irrigation water-wheels, the odor of the bitumen and petroleum wells, the smoke rising from the lime kilns and the furnaces, the great black patches of bitumen intermingling with the pure white deposits of salt, and the steaming salt water of the springs which have all combined to give the place the name "The Mouth of Hell."

In the remotest antiquity the bitumen of Hit was known throughout Babylonia. At Bismya it was used as cement for laying the bricks of a temple 4500 B. C. Of the fragments of marble statues which were discovered in its ruins, the head of one had been broken, and again cemented on with bitumen, and several clay statuettes or household gods, clay and marble vases, and even large cisterns were found, which have been repaired with it. The floors in the toilets of the houses, and in one large public bath, were lined with it. When hardened, it was carved into the heads of animals, or turned upon a lathe into vases, or into cylinders, which were engraved and used as seals. Bitumen was also employed by the jeweler, and most of the gold beads, the ear-rings and brooches of 6,000 years ago, were of thick gold leaf shaped over a filling of bitumen. For inlaying purposes it was also employed.

During the later centuries, the bitumen of Hit was used at Ur, the birth-place of Abraham, and the ruin is now called by the Arabs, Mughir, a word meaning pitch, because the large square bricks of the temple tower are laid in it, and Birs, a tall ruin near Babylon, which scholars are now inclined to identify with the Tower of Babel, is of a similar construction. Probably since the first occupation of the Euphrates valley this product of Hit has been a source of revenue, but never have the valuable springs been of less service to mankind than now. When the country again falls into the hands of a civilized power they will regain their former glory.

*Field Director of the recent Babylonian Expedition of the University of Chicago; 208 W. 120th St., New York City.

A LONG UNDERGROUND TELEPHONE LINE is being constructed jointly by the Chicago Telephone Co. and the Wisconsin Telephone Co. The line when completed will connect Chicago and Milwaukee, and will comprise 90 miles of conduit. One hundred-pair lead-covered cables will be used, the line being constructed according to Professor Pupin's system [Eng. News, Vol. XLIV., p. 133] for long distance telephony. It is expected that this system will give much better results than the present overhead lines as regards clearness, distinctness, etc.

SWITCHING LOCOMOTIVES FOR GRAVITY YARDS, to push trains over the summit or "hump," have been built by the American Locomotive Co. for the Pittsburg & Lake Erie Ry. They are six-wheel engines (0-6-0), weighing 88 tons (14.6 tons per axle), and having a very short wheelbase to facilitate working over the yard switches and frogs, although in other similar yards engines of the 0-8-0, 2-8-0, or even 0-10-0, are used for heavy service. The springs of the two rear axles are equalized, and the rear axle is the main driving axle. The general dimensions are as follows:

Wheels	4 ft. 3 ins.
Journals	10½ × 13 ins.
Wheelbase	12 ft. 0 ins.
Weight of engine	176,500 lbs.
Weight of engine and tender	305,500 lbs.
Cylinders	21 × 30 ins.
Boiler, diameter	6 ft. 8 ins.
Working steam pressure	200 lbs.
Fire-box	40 × 120 ins.
Tubes, No. 450; diam., 2 ins.; length	13 ft. 0 ins.
Heating surface; tubes	2,906 sq. ft.
Heating surface; total	3,112 sq. ft.
Grate area	33½ sq. ft.
Slide valves; travel	5½ ins.
Slide valves; steam lap, ⅞-in.; lead	1-10-in.
Height, rail to top of smokestack	14 ft. 11¾ ins.
Water	7,000 gallons
Coal	10 tons
Tractive power	44,100 lbs.

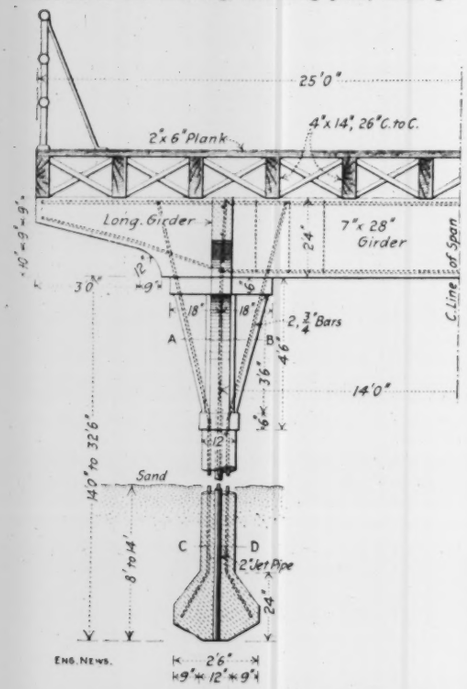
COST OF MAKING AND PLACING REINFORCED CONCRETE PILES AT ATLANTIC CITY, N. J.

The interesting concrete and reinforced concrete work in protecting and widening the well-known Steel Pier at Atlantic City, N. J., was described in our issue of July 26, 1906 (p. 90). We have since received from the resident engineer of the work, Mr. David A. Keefe, a summary of the cost of a representative part of the reinforced concrete work, namely the reinforced concrete trestle of two-pile bents used in widening the promenade sections of the pier. These cost figures are reproduced in the following.

The construction of the trestle in question is shown by the accompanying drawing, reproduced with some additions from our descriptive article above mentioned. Concerning the method of construction, we quote from the same article:

> These piles were molded on end in wooden forms set on small pile platforms built adjacent to the locations of the piles in the pier. The piles were molded with shaft, bulb-point and knee-braces complete. After hardening, the piles were lifted from the platforms on which they were molded, set in position, and sunk into the sand by means of a water-jet having a pressure of 65 lbs. per sq. in. When sunk, the girder molds were built resting on the pile-tops, and the girder reinforcement and concrete were placed.

The complete trestle construction as represented in the drawing, including piles, cross girder, longitudinal girders, wood stringers, floor planking, and hand railing, cost under "average good working conditions," $15.00 per lineal foot of trestle, ready for use. The pile spacing, longitudinally, being 20 ft., this amounts to $300 per panel.



Half Cross Section of 25-ft. Reinforced Concrete Promenade; Steel Pier, Atlantic City, N. J.

As the piles are the principal unusual item, their detailed cost is of interest. The following table gives the cost of a 26-ft. pile [the maximum length was 32 ft. 6 ins.], and the deduced cost per foot of pile:

COST OF 12-IN. x 26 FT. REINFORCED CONCRETE PILE WITH BASE AND BRACKETS COMPLETE; ATLANTIC CITY STEEL PIER WIDENING.

		Costs per pile.
Forms—		
Lumber, 340 ft. B. M., @ $30	$10.20	
Labor (carpenters @ $2.50 per day)	12.00	
Oil, nails, oakum, bolts, clamps, etc	1.20	
	$23.40	$3.90
Times used	6	
Reinforcement—		
275 lbs. of plain ¾-in. steel rods @ 2 cts. per lb.	5.50	
Preparing and setting, 4/10 ct. per lb.	1.10	6.60
Jet Pipe—		
26½ ft. of 2-in. pipe @ 10 cts. per ft. in place		2.65
Setting Forms—		
6 men @ $2.50 per day = $15, set 4 piles.		3.75
Material—		
20/100 cu. yds. gravel @ $1.50 per yd.	1.35	
40/100 cu. yds. sand @ $1.50 per yd.	.67	
1.50 bbls. cement @ $1.60	2.40	4.42
Labor—		
Concrete and labor foreman	3.00	
6 laborers, mixing and placing by hand, $1.75 each	10.50	
	$13.50	3.38
Average number of piles concreted per day.	4	
Removing Forms—		
4 men @ $2.50 remove and clean in half day 4 columns		1.25
1 man @ $2.25 plastering column with cement grout (4 per day)		.56
Jetting 10 ft. into sand—		
Foreman	3.00	
4 men, $2.25 each, handling hose and traveler	9.00	
	$12.00	3.00
Average number of piles jetted per day..	4	
City water pressure used for jetting @ $1.00 per pile		1.00
Superintendence @ $5.00 per day		1.25
Caring for trestle, traveler, material, etc.		4.84
Total cost per pile		$36.60

$$\text{Hence cost per ft.} = \frac{36.60}{26} = \$1.41.$$

THE CHANGE IN GARBAGE DISPOSAL METHODS AT PARIS FROM GRINDING AND UTILIZATION TO INCINERATION.

The removal and utilization of municipal refuse in Paris was described by M. P. Tur, in a paper read before the International Engineering Congress at St. Louis, 1904. The feature of the Paris system, as therein described, was the grinding of house refuse and garbage and its subsequent utilization as fertilizer. M. Tur showed that under existing conditions the grinding method had a decided advantage over incineration; at the same time, he ventured the opinion that when Paris had extended so far that the agricultural fields were unavailable for the disposal of garbage, it would have to be burned. In "La Technique Sanitaire" for Aug. 1, 1906, M. Ph. Delahaye indicates that the time has already arrived when such a change in disposal methods is desirable. The conditions that necessitate this change are peculiar and differ somewhat from those which M. Tur anticipated.

The grinding system in use at Paris was described by M. Tur as follows:

> The garbage is carried to a plant located as near as possible to the centers of removal and reached by a railroad spur, and also, if possible, by a water route. The garbage is dumped into a pit from which it is raised by an elevator after a short sorting. From the elevator it is emptied into a grinding machine formed of two rotating steel-toothed plates, from which it falls into the cars for removal.
>
> This ground garbage looks like vegetable earth mixed with bits of straw and many bits of paper. Its odor is hardly perceptible, can be endured for a long time, and may be removed almost entirely by sprinkling the cars with lime water. The ground garbage can be used in the fields without giving the same trouble as the original garbage, all debris, troublesome or dangerous for the farmers, having been removed.
>
> The inventors of this method, Messrs. Tenin and Pioger, who have turned their business over to the Societe des Engrais Complets, began by building in 1896 a small plant to the north of Paris, in the Station of Saint-Ouen-les-Docks, which has prospered continuously.

The previous method of disposing of the garbage of Paris, which was in use until a few years ago, was by direct removal to the neighboring fields, where it was sold to the farmers. However, fields where it was possible to utilize this garbage became scarcer; the suburban towns made trouble about permitting the passage of the garbage-loaded carts through their streets; and the farmers, now able to buy cheap chemical fertilizers, were willing to pay but little for a fertilizer that required careful sorting from the tin cans, crockery, glass, etc, with which it was mixed. Consequently the bids of the contractors who were hired by the city to remove and dispose of the garbage became higher and higher. The total expenditure, which in 1873 was about $169,000, had quadrupled by 1901, amounting to some $687,000.

The city, accordingly, was glad to enter into a contract with the Société des Engrais Complets for the removal and grinding of the garbage by the process above described, and considerable economy in total expenditure was thereupon derived, although at no time did this company handle the entire quantity of garbage. According to the article by M. Delahaye, the company contracted, beginning with July 16, 1899, to receive the garbage from the second and third boroughs of Paris; from July 16, 1901, that from the ninth, seventeenth and eighteenth; from July 16, 1904, that from the sixth, seventh, fourteenth and fifteenth; from July 16, 1907, that from the third, tenth, nineteenth and twentieth. Of the 20 boroughs of Paris, 13 accordingly contracted for the disposal of garbage by this method.

The economy derived by the city from these contracts is shown by the following decreasing total costs: 1902, $691,200; 1903, $686,800; 1904, $668,600; 1905, $648,800. To the first plant at Saint-Ouen, built in 1896, the company added a second at Issy-les-Moulineaux, and projected a third at Romainville.

During the past year, however, it seems that the company has been financially unsuccessful in its undertaking. The cause suggested for this is the decrease in the demand for its fertilizer on the part of the sugar beet cultivators. This decrease is attributed to the removal by the French government of the premium on the exportation of sugar and to the law of Jan. 29, 1903, which checked the cultivation of the sugar beet. At any rate, the sales of the company, it is said, fell off $14,000 in 1904-5, and $2,675 in 1905-6, and its stock of fertilizer became so large that sufficient storage room for it could not be found in Paris.

Consequently the city of Paris stood confronted with the possible cancellation of its contracts with the Société des Engrais Complets and the likelihood of a return to the old expensive system of merely carting away the garbage. It decided, accordingly, to accept a proposition made by the company for the treatment by incineration of the excess of garbage, so as to limit the production of fertilizer. This was adopted as a temporary measure, pending the time when the grinding process would be altogether abandoned. Under these circumstances the city has agreed to pay to the company the sum of $72,000 annually, until July 15, 1927, at which date the city will take possession of the grinding works and all their equipment. It is expected that eventually incineration will be the sole process employed, although some opposition to it is manifested, notably by the ragpickers, of whom there are from 20,000 to 25,000 in Paris.

WATERPROOFING CONCRETE ON U. S. FORTIFICATION WORK.*

By Emile Low, M. Am. Soc. C. E.†

DEFENSES OF THE COAST OF MAINE.—To stop leaks through concrete in old work the cracks and seams on the top surfaces were calked with oakum and elastic cement or elastic cement alone, or the surfaces were covered with one or more coats of preparations of oil and naphtha or asphalt and naphtha. Two makes of elastic cement were used and are about the same as the brand known to the trade as slaters' cements. These cements are supposed to accommodate themselves to changes of temperature without cracking.

In dampproofing floors of new work two layers of 2-ply tarred paper were put down on a roughly-finished concrete floor about 6 ins. below the true floor, with a coating of coal-tar pitch above, beneath and between the layers of paper.

To make the roofs of rooms and galleries in new batteries waterproof the top of the concrete has been covered with 16-oz. sheet copper in several instances. Hot coal-tar pitch has also been applied to vertical concrete surfaces against which sand fill is to be deposited.

BATTERY BLAIR, FORT WILLIAMS.—A number of efforts have been made to stop leaks in the rooms and galleries between the loading platforms, being evident breaks or failures in the waterproofing. The top finish of the platforms, about 6 ins. thick, rests immediately on

*Abstracts from Technical Details of Engineering Methods on Fortifications, Rivers and Harbors, and other works, Report of Chief of Engineers, U. S. Army, 1904.

†Rome, N. Y.

the waterproof course and was put on in entirely separate concrete blocks, about 5 ft. square. A coating of "stone liquid" was applied to surfaces where the most trouble was found, but the benefits were not lasting. "Stone liquid" seems to be a mixture of a heavy oil and naphtha and is very expensive. A mixture of hard boiled linseed oil and naphtha in equal proportions was afterwards used in place of the "stone liquid."

The seams in platforms were first poured with a heavy oil and caulked with oakum, driven in with a heavy calking tool and mallet, the top of the seam being filled with elastic cement well pressed down. After a heavy thaw it was found that the oakum had absorbed water, swelled, and become loose, and the leaks again appeared. The oakum was removed, the seams enlarged, and after being given a coating of linseed oil, were filled with elastic cement well pressed down.

ELECTRIC POWER-HOUSE, FORT WILLIAMS.—The concrete roof of this house, which showed several bad leaks, has been treated in the same manner as Battery Blair, above referred to, and in addition was given a coating of E-pure asphalt and sand. This is a mixture of asphalt and naphtha, and as it dries very quickly one man applies it with a brush and another follows closely with a thin coating of sand. This was also a failure, both in stopping leaks in the seams and in causing the asphalt to adhere firmly to the concrete. The same results were observed at Battery Daniels, Fort Levett.

ELECTRIC POWER-HOUSES AT FORT McKINLEY AND FORT LEVETT.—The roofs of these houses are of concrete, 4 ft. thick, and were built in sections separated transversely. The planes of separation between the blocks were, of course, sources of leakage, and as a temporary expedient for the winter these seams were covered in the fall of 1903 with strips of prepared roofing paper fastened to the concrete with liquid cement furnished with the paper. This answered the purpose quite well, except that while removing snow at Fort McKinley the paper was also removed in several places, thus causing leaks. Early this spring the strips of roofing paper were removed and the seams cut and filled with elastic cement, as in the case of Battery Blair at Fort Williams. This stopped the leaks, except during two very heavy summer rains, when the water came through in several places. The seams have again been filled with elastic cement well pressed down, and the results have been satisfactory up to the present time, but the prospects of stopping the leaks permanently by this method do not seem promising.

At practically all of the emplacements, where there was any indication of leakage, the platforms and parapets have been treated with linseed oil and naphtha, but only in one or two instances has it seemed to do any good. The same may be said of calking seams with oakum and elastic cement or elastic cement alone.

DEFENSES AT EASTERN ENTRANCE TO LONG ISLAND SOUND.—Linseed oil, sprayed on concrete parapets, was used last year for making the surface nonconspicuous; this year it has been somewhat extensively applied, and it is believed with good results, for waterproofing as well as surface coloring at parapets and outside vertical walls. For the waterproofing raw oil is mixed 3 to 1 with naphtha or gasoline and well brushed in, 2 to 4 coats according to the porosity of the concrete and until the small air bubbles disappear; after which a coat without the penetrating thinner is applied. It is thought that this waterproofing should not be applied to concrete less than about a year old. A number of samples of different mixtures of coal-tar or petroleum basis have been tried in different ways for painting or coating parapet surfaces. The best of these is Durable Roof-Leak, made by the Elliott Varnish Co., New York, and sold in small lots at $1 per gallon. "Hydrolene B," as prepared for the purpose by the Sun Co., Philadelphia, is next in order of merit. The Roof Leak penetrates the concrete a little, adheres well, forms a continuous coat and of enough thickness for sanding. It is not yet known if the coating will stand low temperatures without cracking or peeling off.

DEFENSES OF NEW YORK, N. Y.—In continuing work of dampproofing emplacement rooms, interior linings have not been further constructed, but all experiments have been directed toward excluding dampness by external applications. These applications have been straight run coal-tar pitch and sand, asphalt paints, or solutions of asphalt in naphtha and sand, and boiled linseed oil. In some cases, as at Fort Totten and Fort Hancock, larger cracks had been previously filled with roofing pastes, such as Callahan's cement, which pastes had not been entirely satisfactory. At Fort Totten the superior crests of emplacements Nos. 1 and 2 were treated with hot coal-tar pitch and sand; the cracks, where not previously filled with roofing paste, were cleaned out and filled with the hot tar, each coat being well sanded over until the tar would not stick to a man's shoe when walking over it. Additional sand was placed on warm days wherever the tar showed too soft, or a tendency to run.

Applications of Hydrex compound, which much resembles coal-tar pitch, were also made in similar manner at Fort Schuyler, the compound having been softened somewhat by an admixture of petroleum residium to make it better adapted to flow into the cracks, with similar results. In all cases marked improvement, if not complete success, attended these experiments, but it is evident that the material must be applied at least once a year to give satisfactory results. The coal-tar pitch is so cheap ($16 to $18 per ton) that frequent applications are more economical than copper linings.

At Fort Wadsworth, Batteries Emory, Upton and Barry have for years been extremely wet, and many attempts to better the conditions by filling cracks, etc., have resulted in failure. During the autumn of 1903 the entire superior slopes, the loading and gun platforms were painted two coats (each sanded) with E-pure asphalt roofing cement, the joints and cracks having first been cleaned out and filled with the material.

This paint, being a solution of asphaltum, or bitumen in naphtha, must be used before the naphtha evaporates, otherwise it will not stick to concrete. It is best to take it from the barrel through a molasses gate, as needed, and apply it at once without heating. As fast as it is laid on, sand must be applied, otherwise the rapid drying of the paint will have a glossy surface; the sanded surface is satisfactory for concealing the battery.

At Fort Hancock several emplacements, where leakage was very bad, have been treated with Hydrex roofing paint and sand, the large cracks having been first filled with Callahan's roofing paste. This paint is similar to E-pure asphalt paint, and must be similarly applied.

All recent batteries have been waterproofed with layers of paper and asphalt, and are quite free from leaks. Batteries now under construction are being dampproofed with straight run coal-tar pitch, laid on hot, upon from three to five thicknesses of roofing felt. The coal-tar pitch and Hydrex compound, a similar substance, seem to resist the salts dissolved from the concrete better than asphaltum compound and seem to be growing in repute compared with asphaltum for waterproofing.

DEFENSES OF HAMPTON ROADS, VIRGINIA.—This battery was constructed of Rosendale concrete in 1896-97. Its upper surface was sloped for drainage, plastered with cement, and afterwards coated with asphalt before being covered with sand. In spite of this, however, the rooms and galleries were very wet, mainly from seepage water. This water in passing through the concrete became impregnated with carbonates which were deposited in the shape of stalactites and stalagmites, which were numerous.

DAMPPROOFING BATTERY BRUMLEY, FORT SCREVEN, GA.—This battery was built in sections, with vertical planes of weakness. The magazines were damp and passages wet at all times. Outside waterproofing, as applied lately, i. e., during the past fiscal year, has proved very satisfactory, and the battery is now practically dry. The method employed was as follows:

The crack between the parapet wall and the apron was filled with hot insulatine, and the cut-off surface of the apron, the groove, and exposed face of parapet wall were painted with asphalt, applied hot. The parapet fill along the entire front of the battery was thrown back down to the toe of the apron, the concrete was dried, cleaned off and then waterproofed with insulatine, applied hot. Care was taken to see that the surface was thoroughly covered. All cracks in the horizontal surface of the concrete were cut out 1 in. wide and ¾ in. deep (some large cracks were cut wider), cracks cleaned out and hot asphalt mixture poured in and ironed down smooth with the surface of the concrete. After the cracks were finished, all of the exposed horizontal surfaces of the concrete were painted with two coats of boiled linseed oil and lampblack, applied hot. All vertical surfaces were painted two coats of plain boiled oil and then one coat of slate color (lead, oil and lampblack). The concrete should be dry and the weather warm when the oil is applied. Later, one coat of tar paint was applied to the parapet surface. This coal-tar paint was composed of coal tar, asphalt and coal oil, mixed in the following proportions, viz.:

Coal tar	4 gallons.
Asphalt	1 "
Coal oil	1 "

If any cracks develop after the first coating it is evident that the quantity of asphalt in the mixture is too great, and in other applications should be reduced. This should be allowed to dry for a time, and if it remains sticky, should be sanded. The sand gives it a color approximating that of the surroundings.

DEFENSES OF THE COAST OF FLORIDA AT KEY WEST AND TAMPA.—During the fiscal year emplacements for 6-in. and 3-in. guns have been constructed at Key West and Fort Dade. In all of these batteries the rooms are in traverses covered with sand. The dampproof course is between the concrete and the sand. At Key West asphalt mastic was used, as a quantity of this material was on hand. The top of the concrete was covered with smooth plaster, proper slope being given for drainage. Above this the asphalt was placed in two layers, making a total thickness of about ¾ in. The composition of the asphalt was as follows:

Rock asphalt mastic	440 pounds.
Coal tar	3 gallons.
Siliceous sand	5 "

After hardening, this was covered with sand. At Fort Dade, Hydrex felt was used for the dampproof course. The top of the concrete was covered with smooth plaster and given a proper slope for drainage. A double layer of Hydrex felt was then applied, the strips of felt being lapped three or more inches and coated with Hydrex cement. The joints of the second course were placed midway between those of the first course. The upper surface of the first course was entirely coated with Hydrex cement before the second course was placed over it.

At both Key West and Fort Dade the vertical walls were plastered after the forms were removed. Before plastering, the surfaces were thoroughly saturated with water, then a coating of thick grout was brushed in. After the grout had attained its initial set the plaster was applied, firmly pressed into place, and floated to a smooth surface. The vertical walls retaining sand fill were given a thorough coating of hot coal-tar. All rooms are perfectly dry.

DEFENSES OF MOBILE, ALA.—The following methods have been used on new work where the concrete had a vertical cover of earth:

The top of the concrete was covered with a thin coat of 1 to 2 cement mortar and given a rough trowel finish. As soon as the surface was sufficiently dry it was covered with a layer of asphalt mastic 1 in. thick, and rubbed down to a finish with dry sand and cement in equal parts. To prepare the mastic, take 500 lbs. of Diamond T asphalt mastic, broken into small pieces, 30 lbs. of Diamond T asphalt flux, and 5 lbs. of

petroleum residium oil. When thoroughly melted add 400 lbs. clean, dry torpedo gravel, previously heated. Stir gravel and asphalt until both are thoroughly mixed at a temperature of about 375° F. While this makes a desirable waterproofing, it has the advantage of not slipping under pressure of the earth covering at any reasonable angle.

THE RELATIONS OF HARBORS TO MODERN SHIPPING.*

By W. H. Wheeler, M. Inst. C. E.

The continual increase in the size of ships is a well recognized fact, but the rate at which this increase has been going on is hardly realized. Although during the last few years a very large amount of money has been expended in various countries in improving harbors and waterways, maritime works for the accommodation of large vessels have not kept pace with the ships, and the port and dock engineer is behind the shipbuilder. Up to a certain limit the increase in the size of ships is likely to continue, as it has been shown by theory, and also by practical experience, that the larger the ship the less the proportionate cost of working, and, therefore, the less the cost at which merchandise can be conveyed, and the greater the profit to the shipowner.

Any port that now wishes to remain in the front rank must provide accommodation for the largest class of cargo carrying vessels. The number of ports equipped for this trade is, however, limited, not only on account of the enormous outlay involved, but on account of the expediency of concentrating the traffic at a few representative centers, so as to secure a sufficient tonnage to warrant the cost of the necessary works, and to facilitate the rapid transit of merchandise to and from the great centers of industry. In addition to the construction of works such as the entrance locks to docks, and deep water basins and quays, a first-class port must be provided with adequate means of repairing and surveying vessels of the largest dimensions.

The present tendency of transportation is to increase the volume to be moved in one vessel, and it has become a settled axiom that the larger the vessel the better the results to the shipowner. The fact must not be lost sight of by the shipowner, that although transport can be conducted in large and deep draft vessels at the most economical rates, yet, as the enormous cost required to provide accommodation for these mammoth vessels must ultimately be paid for by ship and cargo, the saving in the cost of transport may be more than compensated by the increased dues that must be levied on the merchandise, or the shipping, to pay for it. A strong argument is thus provided for concentrating the accommodation for the largest class of steamships at as few representative ports as possible, and thus commercially to warrant the required expenditure, as above noted.

The average tonnage of the 20 largest steamships has increased during the last half-century from 310 tons to 1,955 [long] tons. Their average length in 1848 was 230 ft.; in the next 25 years this had increased to 390 ft.; in the succeeding 25 years to 541 ft., and in the last available returns it was 640 ft. The average loaded draft of these steamships increased from 19 ft. in 1848 to 24 ft. in 1873, 29 ft. in 1898, and 32 ft. in 1903. The number of vessels drawing more than 24½ ft. rose from 386 in 1899 to 566 in 1903; the number drawing 26¼ ft. rose from 36 in 1902 to 48 in 1903, and in 1904 to 185. At the present time there are 17 vessels afloat drawing 32 ft. and upwards, the draft of the deepest being 36 ft. when fully loaded.

Comparing the dimensions of the twenty largest steamships in 1848 (say 230 ft. in length, 36 ft. in breadth, with a draft of 19 ft.) with those now in use (say 640 ft., 69 ft., and 32 ft., respectively) it will be seen that while the length has increased 177% and the breadth 91%, the draft has only risen by 68%. If the last 22 years be taken, the ratio of increase has been: length, 39%; breadth, 53%; and draft, 33%.

The reasons why length and breadth have outstripped draft is obvious. Vertical room cannot be as easily provided at ports as horizontal space. It is here that the difficulty of the navigation comes in. In a tidal river or dock the horizontal space may be abundant, but the trouble is to secure the depth. The most important dimension that has to be considered in a ship is the draft. Recently, however, owing to want of the required depth of water at the ports there has been a tendency for the proportion of increase of breadth and length to exceed that of depth. Naval architects have expressed the opinion that it is of far greater importance to increase the draft of steamships than to go further at present with the length and breadth; and they are constantly urging the necessity for increased draft in order not only to obtain greater carrying capacity at less cost, but also greater stability and increased speed.

Sir William White [Past President of the Institution of Civil Engineers and formerly Chief Constructor of the British Navy Department] has stated that "depth of water is a crying need for economical ship construction and propulsion. The length and breadth have been extended far beyond the proportion in which the draft of the ship has been increased, and this involves unfavorable conditions for speed and dead weight capacity." He has also shown that the freight-earning capacity of some of the American liners which now only carry from 500 to 600 tons cargo would be nearly trebled for 1 ft. extra draft, and increased five-fold for 2 ft., with a very trifling loss of speed. For vessels of 3,000 tons gross, built to carry cargo as well as passengers, each additional foot of draft would increase the carrying capacity nearly one-third, and 3 ft. would increase it two-thirds. Such ships, if they had their proper proportion of depth, could be laden more deeply with greater safety, and would yield a sensible economy in freights. As a matter of fact, it is in the direction of deeper draft that the best results are possible; and unless a greater depth of water can be given, an absolute limit of speed, as well as cargo-carrying capacity, is imposed.

Arranging the British shipping into classes, vessels of the first-class may be taken as the liners running between that country and the United States, in which service everything has been sacrificed to speed and the requirements of passengers, very little cargo being carried. There are at the present time 16 British steamships engaged in this service, six German liners, and four belonging to the United States. The dimensions of these vessels vary from 500 ft. to 726 ft. in length, from 27 ft. to 33 ft. in draft, and from 8,000 to 20,000 gross tonnage.

With regard to the dimensions of the first-class ship of the future, Sir William White has expressed the opinion that a first-class port should have provision for ships up to 1,000 ft. in length, 100 ft. breadth of entrance, and 33 ft. to 35 ft. draft of water. This draft of 35 ft. means a depth of water of 38 ft. in the entrance channels and over sea bars, 37 ft. in river channels, and 36 ft. over lock sills and in harbors, and along quays and wharves Events are leading rapidly towards these dimensions. The two Cunard steamers, "Lusitania" and Mauritania" have a length of 785 ft. by 88 ft. beam, and they have nearly the draft given by Sir Wm. White, 34 ft. to 35 ft.

There is not in this or in any other country a port that has sufficient depth of water to allow of the navigation of the largest vessels of this class at low water; and there are only two ports where works are in progress for providing such a waterway. Neither are there in existence any dry docks where such vessels could be repaired. It does not, however, appear to be reasonable that shipowners should demand that their vessels should be accommodated at any state of the tide. With the exception of the passenger trade between this country and New York no sufficient commercial advantage could be gained by incurring the enormous outlay involved in reconstructing waterways and locks so as to afford admittance to the vessels at low water.

Steamships of the second-class comprise those carrying passengers, mails, and cargoes on long distant voyages. The size of these vessels going to the Far East through the Suez Canal is limited by the depth of this waterway, which at the present time does not allow of a greater draft than 26½ ft. The largest steamship running on this route is 500 ft. long, and 8,000 gross tonnage. For the Atlantic and Pacific ports, including the United States, Canada, South America, and Africa, and also for vessels going round the Cape to Australia and New Zealand, the vessels at present engaged range from 450 ft. in length and 6,000 tons gross tonnage, with a draft of 24½ ft., to 605 ft. by 65 ft., 13,500 gross tonnage, and 32 ft. draft. Until considerable alterations are made in the existing accommodations, both in this country and abroad, in the depth of waterways, locks, and dry docks, the larger of these dimensions is not likely to be much increased.

For this class of steamship, the standard accommodation for first-class ports so far set up by port authorities appears to be a depth of 30 ft. at high water. This depth is that advised by the Royal Commission on the Thames Improvement for the approach channel to the port of London, and to this depth it is now being dredged; it is also the depth to which it is stated that the bar of the Mersey below Liverpool is ultimately to be deepened, and it is the depth of the channel to Southampton, and at the quays. The ultimate depth as at present determined for the Suez Canal is one foot more than this.

The third class comprises the largest cargo vessels, including the largest class of tramp or cargo and coal boats not attached to any particular port; these vessels being liable to be ordered to any foreign port are restricted in their dimensions to the accommodation available abroad. The dimensions of the largest vessels may be taken as ranging up to 7,500 tons gross, 500 ft. in length, 56 ft. broad, and with 27 ft. draft. There are, in addition to London, Liverpool, and Southampton, 13 ports in Great Britain that can accommodate these vessels.

From the above figures it will be seen that ports that aspire to provide accommodation for the larg[est] fast passenger and mail steamships must be [able] provide at least 40 ft. at high water; and [where] are docks with entrance locks these will [have] 1,000 ft. long and 100 ft. wide. For the lar[gest] ger mail and cargo boats, the future dime[nsions] probably approach 850 ft. in length, 80 ft. br[oad] 38 ft. over the sills at high water. For the [largest] the dimensions are already approaching those [of] the second class, namely, 850 ft. length of l[ock] wide, and 36 ft. depth of water, the vesse[ls] from 20,000 to 25,000 gross tonnage.

LONDON.—The depth of the present navig[able] nel up to Tilbury docks, which are situated [at] mouth of the river, is 26 ft. and 39 ft. at low [and] water, respectively. This is now being dredge[d] at low water. The lock at Tilbury Dock is 7[00] by 80 ft. wide, with 23 ft. over the sill at l[ow] and 38 ft. at high water, the latter allowing [the] of 13,000 tons gross to enter the docks. Th[e] dry dock is 875 ft. long by 70 ft. wide, with [30] water on the sill at high tide. The present [depth] of the channel above Tilbury up to the Alber[t] where some large passenger steamers berth, is 2[6] Royal Commission advised that this should be [deep]ened to 30 ft. The length of the locks at the entran[ce] the Albert Dock is 550 ft., and the width 80 ft.; the [depth] of water over the sill 13¼ ft. at low water, and 2[7] ft. at high water.

LIVERPOOL.—The bar at the entrance to the Mersey has been dredged so as to give at the present time 27 ft. at low water, and 47½ ft. at high water. It is proposed to continue the deepening up to 30 ft. at low water. The largest lock at the entrance to the docks is 90 ft. in width. The sill gives a depth of 11.75 ft. at low and 32.25 at high water. A bill is now being promoted for power to construct entrances to the docks 130 ft. wide and 40 ft. deep. The largest dry dock is 925 ft. long and 94 ft. wide, with 32 ft. over the sill at high water.

SOUTHAMPTON.—Owing to its depth of water, and central position for collecting and delivering cargo, this has become the port for a portion of the United States fast passenger traffic; and also for vessels engaged in the South African and West Indian mail and passenger boats. The approach channel and quays have 30 ft. at low and 39½ ft. at high water, and 35 ft. over the sill of the Empress Dock, which is entered on the level without any locks. It has the advantage of practically four hours high water. The dry dock is 875 ft. long, sufficient for the present largest vessel, and can be extended to 1,000 ft. Power has been obtained to deepen the waterway to 35 ft. at low water.

DOVER.—This will soon become a great naval harbor, and is the principal port for the cross-channel traffic to France; it is relatively small as a commercial port. It has a depth in the harbor of 29 ft. and 44 ft. at low and high water at the Prince of Wales Pier, and when the alterations now proposed are completed, the depth at the Admiralty Pier for mercantile purposes will be 40 ft. and 50 ft.

PLYMOUTH.—This is a port of call for some of the larger mixed cargo and passenger steamers. There is a depth in the harbor of 30 ft. and 41½ ft. at low and high water, with 24 ft. and 35½ ft. at the quay.

[From figures given in the above paper and from other sources we have compiled the following table of depth of water at about 60 ports in various parts of the world.—EB.]

DEPTH OF WATER AT HIGH-WATER AT VARIOUS PORTS.

(Figures in parentheses represent the adopted increased depth.)

	ft.		ft.
New York[1]	34 (44)	Hamburg	26 (32)
Boston	45	Bremerhaven	32
Philadelphia	30	Barcelona (old port)	20
Charleston	30	Bilbao	19
New Orleans	28	Cadiz	41
Galveston	30	Malaga	32
San Francisco	35	Lisbon	unlimited
Quebec	42	Oporto	18
Montreal	27½ (32)	Genoa	32
Panama Canal	35	Brindisi	20
Vera Cruz	33	Riga	32
Coatzacoalcos[2]	50	Cronstadt	18
Salina Cruz[3]	33	St. Petersburg	22
Mexican ports[4]	33	Stockholm	23½
Porto Rico	24	Malmo	32
La Plata	21 (30)	Copenhagen	30
Montevideo	24 (30)	London	24 to 39
Calcutta	39	Liverpool	47 (50½)
Colombo (Ceylon)	34	Southampton	(44)
Rangoon	38	Dover	(50)
Hong Kong	46	Plymouth	41½
Havre (France)	33	Bristol	32
Dunquerque	31	Grimsby	44
Boulogne	36	Hull	30
Calais	30	Cardiff	32
Marseilles	52½	Newport	33
Antwerp	26 (31)	Swansea	33
Zeebrugge	38½	Glasgow	30½
Rotterdam	26		
Bruges Canal	26		
Amsterdam Canal	30		
Kaiser Wilhelm Canal	27¾		

[1]Low water at New York, 30 ft. [2]On the bar 30 ft. [3]Low water. [4]Adopted standard for Mexican ports 33 ft.

*Condensed from a paper in "The Engineer," London, and supplemented by figures in tabular form, from other sources.

CONSTRUCTION AND MAINTENANCE OF STREET RAILWAY TRACK.*

By M. Neilson.†

We should strive to get street railway track construction down to a standard, and in order to do this we must first decide what form and weight of rail is best adapted for paved streets, macadam streets and suburban lines. The next point will be the kind of joint plate that will give the most satisfactory results, and then a plan of construction which will withstand our severe climatic conditions.

The old tram-rail track construction was considered good in its day, but the increased weight of cars introduced with electric traction called for a more substantial track construction, and the tram-rail was superseded by heavier forms of girder rail, also light tee rail. There have been many different kinds of lipped (or grooved) rails made, but the majority of them have proved unsatisfactory. When they were introduced, many got the idea that nothing else would suit for city streets, paved or unpaved, the tee rail being considered only fit for suburban lines. The heavy lipped rail used as a guard on curves and at intersections is well adapted for the work it has to do, but lipped rails generally have too little depth allowed for wear, so that the flanges of the wheels soon come in contact with both the side and bottom of the lip. The groove is a receptacle for dirt, stones, pieces of wood, iron, etc., and the cars pounding over these obstructions and grinding against the lips tend to loosen up and hasten the wear on the rails and make too much noise. In particular sections and cases where the tee rail will not be allowed the heavy lipped or "Trilby" section should be used; the shape of the groove on this is very much better than in some of the earlier designs. It tends to clear itself of dirt but is a bad receptacle for pieces of iron.

In endeavoring to fix upon a standard rail we must not forget to consider it from an economical point of view, and try to get one which with a minimum weight of metal will withstand the most severe traffic conditions, will wear longest and cost least for maintenance of track and pavement. The latest section of grooved rail weighing 96 lbs. per yd. is not an economical design; there is too much superfluous metal in the lip, which adds to the first cost, and it invites the traffic of heavily loaded wagons. In fact, it tends to concentrate all travel on the rails or in their vicinity, thereby obstructing the progress of cars and wearing out the pavement adjacent to the rails.

By adopting a good tee rail we can reduce the frequency of renewal. It has been alleged that a satisfactory job could not be made with tee rail in paved streets; this is not correct; excellent track work can be made, leaving the streets in shape so that the rails can be easily crossed in any direction in perfect safety. Grooved rails are responsible for a lot of damage to the wheels of light vehicles, and I have seen rubber tires stripped off by catching in the grooves. It is possible that the blocks along the gage side of tee rails will require more attention; if so, we can afford to renew and maintain them in perfect order, as the difference of the cost of the superfluous metal in a lipped rail and the greatly increased life of a good heavy tee rail will more than compensate for any additional expense that may be incurred in keeping the paving blocks in good shape. This rail makes an easier riding track, with less noise, and also discourages teams from driving along the track. I believe that for straight tracks the tee rail will soon be adopted as standard, and that the many forms of lipped rail will become obsolete. Having decided upon tee rail as standard, we must next fix on a particular rail for use in paved streets and another for macadam streets and suburban lines, which, with the heavy lipped guard-rail, will make only three different kinds of rail required to be kept in stock.

Where tee rails are used in streets paved with granite blocks several ways have been devised to form a groove for the flanges of the car wheels. If great care is not taken in cutting and laying the grooved blocks, the groove is apt to be like the blocks, rather rough. Granite paving costs, roughly, about twice as much as scoria (or slag) blocks. The scoria blocks should wear well, as a much smoother surface can be made with them, thus lessening the shock and wear by heavy wagons and carts pounding over a rough surface. Special scoria blocks can be molded to any pattern required to form an excellent groove for the flanges of car wheels. The noise made by heavy wagons on granite blocks is very objectionable; therefore I think that scoria blocks will soon be more extensively used and good results will be obtained if a solid foundation is made for the blocks as well as the rails.

For paved streets a tee rail 60 ft. long and weighing about 90 lbs. per yd. is good for the heaviest cars likely to be used. It should have sufficient depth to allow the laying of 6-in. paving blocks; the base should be broad and the head wide and deep in order to insure long life under severe traffic conditions. For macadamized streets I would adopt a tee rail 60 ft. long of the Am. Soc. C. E. 80-lb. section; and for suburban lines the same section of rail in 30 ft. lengths.

A track is weakest at the joints, and the destruction at this point has in many cases been accelerated by careless construction work—either too much was allowed for expansion, the bolts were left slack, or the ties were insecurely bedded and not placed properly. Many different kinds of rail joints have been tried, and the use of the tee rail makes the joint problem somewhat easier to solve. Where track is laid in paved or macadam streets without allowing for expansion, with heavy angle plates 28 ins. long, and six bolts at each joint, properly tightened, they should support the ends of the rails in such a manner that the joint can hardly be detected after cars have rolled over it for a time. What is known as the Continuous joint, with four or six bolts, is also good and seems well adapted for what we are all striving to obtain, something that will support and keep in position the ends of the rails so that they will appear as a continuous band of steel, and cars will roll along so smoothly that it will be impossible to detect the joints.

Track in paved and macadam streets should be laid without any allowance for expansion. The rust and dirt should be removed from the rails and splice plates where they come in contact, and before putting on the plates the ends of the rails should be brought into line and to same elevation; damage is often done by trying to force plates to bring the rails into proper position. After the rails are brought to the correct grade and properly lined, the joints must be gone over by a man who will hammer the plates and bolts well into place and tighten up the nuts as much as it is possible to do with a 4-ft. wrench. It will be found that a considerable amount of slack can be taken up after the rails are in proper position. As the bolts cannot be seen after the work is completed, we must endeavor to have everything as tight as possible when the track is laid.

In streets and every place where only the tops of the rails are exposed, they should be laid so tight that there is no space left to start pounding; in such a case the joints may be made either even or staggered, but on suburban lines (with exposed rails) where an allowance must be made for expansion and contraction it is better to break the joints. If track laid with staggered joints is not kept in good order, cars passing over it at a fair rate of speed get into a disagreeable motion and list very perceptibly. In such cases, where there is double track with very limited clearance for cars, the danger of their hitting is somewhat increased. No track should be allowed to get into bad shape. Low loose joints, bad surface, poor line and defective gage increase the destructive force exerted by the wheels, consequently the rails wear out much faster than they should.

The foundation of track is a matter of great importance; good rails are soon ruined if the foundation is defective. One of the worst conditions is where track has the ties laid on clay; and the cost of attempting to keep the track in condition far exceeds a fair rate of interest on the sum which would be required to be expended to make a good foundation. With tee rail track properly laid on a solid bed, the trouble with loose joints should be greatly reduced. Heavy tie rods placed 6 ft. apart will hold the rails to gage and keep them in better line, thereby lengthening their life and at the same time very materially reducing the cost of maintaining the rolling stock.

For concrete foundation in paved streets the standard construction of the Twin City Rapid Transit Co. (of St. Paul and Minneapolis) is excellent, and may be briefly described as follows: The rails are laid on ties 12 ft. apart (these are merely for use in bringing the rails to correct surface), and tie-rods are put in every five or six feet. They cast-weld the joints, but this, I think, should be omitted. When the track is properly surfaced and lined a trench is excavated under each rail, with a uniform width of 2 ft., and of sufficient depth so that there will be 12 ins. of concrete under the rail, the height of the concrete being made to suit the kind of paving material. The balance of the space between these longitudinal concrete stringers is made 6 ins. thick to support the paving blocks. Care should be taken to prepare the foundation for the concrete so that the section will be as nearly as possible uniform for the whole length of the track. Great care should also be taken with the earth foundation upon which the concrete is to rest. It should be well rammed or rolled to an even hardness. These details are too often looked upon with indifference as being matters of no importance.

When relaying track in streets which were concreted when track was first laid some stretches will probably be good solid concrete and some stretches will be of no use; all the old concrete in the bad stretches should be removed and new work of the Twin City standard plan put in. Where the concrete is of good quality, probably broken into large slabs which rest upon a well-settled earth bed, it seems to me unwise to disturb the old concrete. In cases like this in Montreal we laid the rails on top of this work, held together only with tie-rods 6 ft. apart. The rails were shimmed to correct grade, everything loose on top of the old concrete was removed, and the whole surface was kept well moistened ahead of the new layer of concrete, which varied in thickness according to the settlement that had taken place under the original mass. In cases where no settlement had taken place and there was not sufficient depth to allow the new concrete being tamped under the rail, pure cement mortar was run under. Where entirely new concrete work is put in, no cars should be allowed on the rails for at least ten days after the last batch of concrete is laid; good work is sometimes ruined by allowing traffic on it too soon.

* Abstract of a paper read at the semi-annual meeting of the Canadian Street Railway Association.

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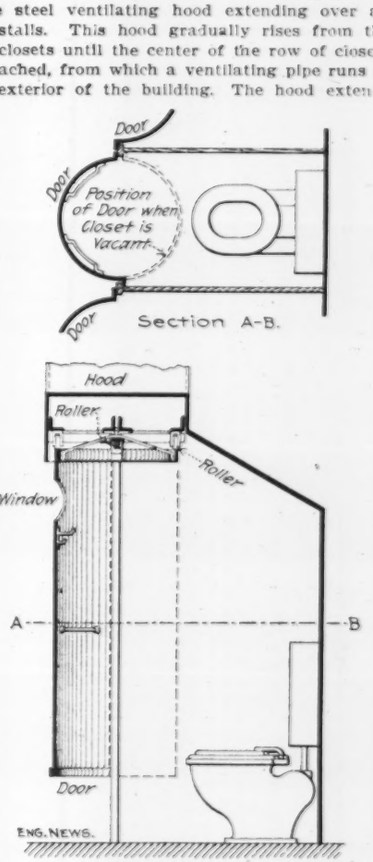
THE BROWN SHOP WATER CLOSET.

The new shops of the Brown Hoisting Machinery Co., of Cleveland, O., have been equipped with a new style of shop water closet. These closets consist of a series of stalls constructed of reinforced concrete and are of the Ferroinclave construction. The walls are supported by light angles, while the closets are covered by a concrete steel ventilating hood extending over all the stalls. This hood gradually rises from the end closets until the center of the row of closets is reached, from which a ventilating pipe runs to the exterior of the building. The hood extends out over the doors, while the partitions separating the different closets are of such a height as to leave an air passage between them and the hood. The doors, the interesting feature of these closets, are semi-cylindrical shells of steel plates extending from the hood to near the floor. They are hung from the top by rollers, running on steel angles, similar to rolling doors, but are arranged to rotate around a vertical axis. The accompanying figure shows the general arrangement of one of these closets.



Cross-Sections of a Brown Sanitary Closet.

The advantages claimed for this style of closet over the ordinary side-hinged door style are: Saving of space, about 3 ft. being saved by this door; ease of cleaning and good ventilation; can be located in exposed positions, since the interior is at all times closed to outside view; it reduces the amount of loafing done by the men, since, if occupied, the door shows it and then also the closets are comparatively dark, thus preventing reading, etc.

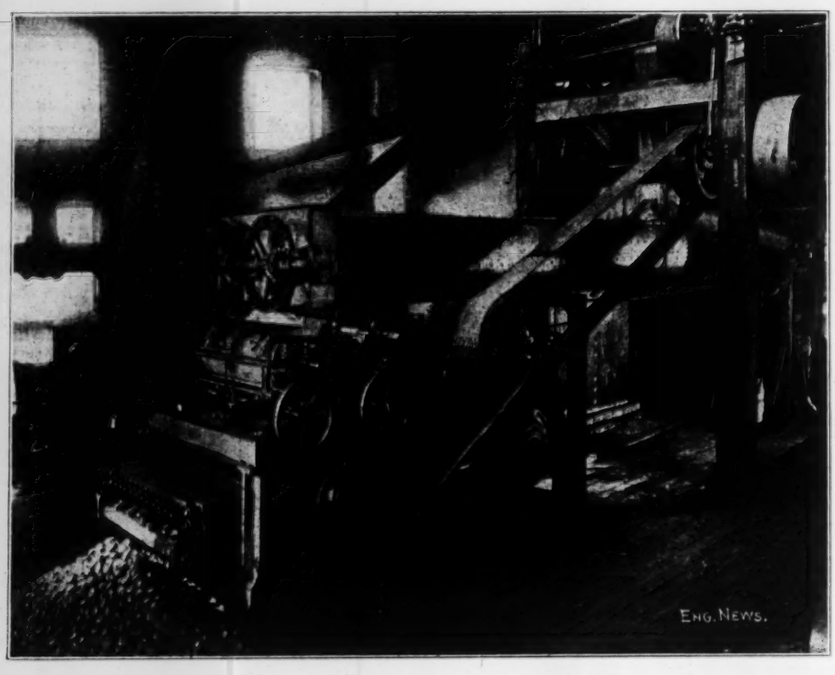
These closets were designed and patented by Mr. Alex. E. Brown, and are now being manufactured by the Brown Hoisting Machinery Co.

A MACHINE FOR BRIQUETTING WASTE COAL.

In the production of coal there is a large proportion of loss from the amount mined owing to the dust and slack, which has little commercial value, while with the softer grades of coal the additional loss through crumbling and disintegration in shipment and handling is also serious. Since the waste is due to the physical condition of the coal, the builders of briquetting machines have considered that the restoration of this waste coal to a condition making it available for fuel should be a profitable enterprise, but although several machines have been tried at different times in this country none have as yet come into any extended use. The reasons for this are partly mechanical and partly commercial. In Europe, where the utilization of wastes of various kinds has been carried to a much higher degree than in this country, the briquetting of coal has been an established industry for several years. This matter is one of the subjects of investigation at the fuel-testing plant now being operated by the U. S. Geological Survey at St. Louis, Mo., and which has been described in our issues of Sept. 29, 1904, and April 5, 1906. Mr. O. T. Malcolmson, Engineer in Charge of the testing plant, states that in general the semi-anthracite coals appear to offer the best field for briquetting, and make the best briquettes. This is due to the large margin between the prices of lump and slack coal, and to the cleaner quality of the semi-anthracite on account of its peculiar physical structure. Coke breeze can be briquetted either with or without coal, and makes a very good fuel, except that it is usually high in ash and very dirty. In practically all the experimental work the bonding medium has been coal tar or water-gas pitch. It is believed, as the result of the investigations and tests made in connection with the fuel testing-plant, that there is a promising future for the development of briquetting in this country, and that fuel briquettes will find a good field for certain classes of domestic fuel as well as for railway, steamship and general boiler work.

Several briquetting machines of this class were described and illustrated in our issue of Feb. 12, 1903. One of the later machines is the Renfrow machine, the first of which is now installed at the fuel-testing plant above noted. It is built by the Renfrow Briquette Machine Co., National Bank of Commerce Building, St. Louis, Mo. The machine is intended for treating all kinds of waste coal, but has as yet been used only on bituminous and semi-anthracite wastes. From the experience with an English briquetting machine at the same plant (built by Wm. Johnson & Sons, of Leeds, England), it is considered that good briquettes can be made with anthracite waste or culm.

The Renfrow machine is shown by the accompanying view. It produces briquettes (termed "coalettes" as a trade name) which are of cylindrical form with rounded ends, 3 ins. diameter and 2½ ins. thick, averaging ½-lb. in weight. A machine now being built will make a larger size, weighing about 1 lb. each. These two sizes are considered the best for domestic and industrial purposes. It is stated that bituminous coals that contain a fair percentage of natural pitch can easily be treated, as can semi-bituminous and semi-anthracite coals that are sharp in grain or texture. Anthracite dust and slack, as well as coke breeze, require a special process of mixing. It has been found that common gas-house or coal-tar pitch makes a good binding material for most grades of coal, the proportion of binder varying from 4% to 8%. The temperature of the mixture and the pressure to be given in the molds depends to some extent upon the character of the coal.



MACHINE FOR BRIQUETTING WASTE COAL.
Renfrow Briquette Machine Co., St. Louis, Mo., Builders.

In the process of briquetting, the proper proportions of the coal and pitch are weighed automatically from storage bins and the mixture is then run through a grinder of the hammer type which reduces the materials to the desired size. Rolls will not handle pitch satisfactorily. The mixture is then elevated and delivered into two vertical cylindrical steam-jacketed heaters, through which it is forced downwards by self-cleaning blades on a vertical shaft and under steam pressure. In order to drive off the sulphur, the temperature is about 375°F. for coals containing a small percentage of sulphur, or 425° F. for coals with a higher percentage. From the heaters the mixture passes to two trough-shaped steam-jacketed mixers which have self-cleaning paddles to stir the material and force it gradually to the end of the machine. Live steam is admitted to the mixer in such amount as to make the mass plastic before it reaches the feeding mixer which delivers a certain amount of the material intermittently. From this it falls to the hopper of a lower feeding mixer, where it is given a final mixing and then goes to the die filler, the quantity delivered to the dies or mold being regulated by a gate. The mold is a chamber, the ends of which are closed respectively by the horizontally-moving dies and the plunger, each of which has a concave face to form the rounded end of the cylindrical briquette. The top of the mold is closed by the plunger during compression. The die and plunger then come together to compress the material within the mold, and when the full pressure has been exerted and the plunger withdrawn the die continues its forward movement, thus ejecting the briquette from the mold. The plungers are operated by rods attached to a heavy guiding or cam-box which surrounds the cam, on a transverse shaft, and is thus given a reciprocating motion. The pressure is about 1,200 lbs. per sq. in., and the ejected briquettes fall upon a conveyor belt which transfers them to the bins.

The machine at the St. Louis coal-testing plant is driven by belting from a countershaft, and requires about 25 HP. when running. It produces 24 briquettes at each stroke, and is run at 12 to 14 r. p. m., according to the class of coal under treatment. It can produce from four to five tons of briquettes per hour, depending upon the weight of the coal and the ease with which it can be briquetted; it requires the services of five men (2 skilled men and 3 laborers) to operate it and handle the raw material and product. The larger machine will be run at higher speed and will probably have a capacity of about eight to ten tons per hour.

THE CAPACITY OF THE CONTACT BEDS of the sewage works of Oldham, England, has decreased as follows since the beds were put in operation:

Time in use.	Capacity of bed.*
¾ year	41 per cent.
1¼ years	36 " "
1½ "	35 " "
2¼ "	30 " "
3 "	28 " "
4½ "	22½ " "
5 "	20 " "
5½ "	19 " "
7 "	19 " "

*The capacity of a bed when first filled is about 50%. The total capacity of the bed (100%) is the capacity of the bed before any clinker is added.

The foregoing figures relate to beds constructed of "mill ashes," or what we here should call cinders. The beds composed of destructor clinkers have not yet been in use long enough to afford definite figures regarding their loss in capacity. These figures have been taken from the annual report of Dr. James B. Wilkinson, Medical Officer of Health for Oldham, and were found in the section of the report prepared by Mr. A. H. Valentine, chemist in charge of the works. Some interesting remarks by Mr. Valentine, on the extraction of grease from sewage sludge, may be quoted as follows:

Reference has been made in previous reports to the question of extracting fat from the dried acidified sludge. Quite distinct from the consideration of a possible profit in any operation of this sort, it must be remembered that the time is not far distant when the valley at the works will not be able to hold any more pressed sludge. More or less of this portion of the works will be required for filtration extensions. In face of this contingency, it would be expedient to consider any feasible method of solving the sludge problem. To my mind, the solution may be found in some form of fat extraction. Roughly speaking, there are two methods of extraction. The one is by the continued action of solvents such as benzene and carbon-tetra-chloride, the other by distillation under reduced pressure. Of the two, it is likely that the latter method would prove less troublesome and less costly. . . . . It is probable that by slightly acidifying the sewage also before it entered the tank a greater amount of stearic acid could be obtained. The market value of pure stearic acid is well over £25 ($120) per ton. The distilled fat, which is lightish gray in color, from our sludge would certainly fetch at least half this price.

The following is a typical analysis of fat-extracted sludge from which previously about 22% of its original weight has been extracted by benzene:

Volatile matter = 45%	{of which Nitrogen = 2.1% and Carbon = 28% (about).
Silica (in various forms)	40.0%
Ferric Oxide	4.3%
Alumina	.5%
Lime	4.2%
Magnesia	1.1%
Sulphuric Oxhydride and Alkalies	Not estimated.
Phosphoric Oxhydride	1.4%

Judicious mixing with small quantities of lime (to counteract acidity), and probably of basic slag in order to increase the percentage of phosphates, would enhance the value of this residue as a marketable manure.

Mr. Valentine recommends that a small experimental fat distillation plant be established. He states that the present method of sludge disposal, by stacking on land, "entails a dead loss of at least £1,400 ($6,800) per annum."

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Large ocean ports are at present facing problems of enlargement to accommodate the increasing size of steamers and the growing number of large steamers. According to an English engineer of large experience in harbor works, who is quoted at length elsewhere in this issue, the increase or accommodation for steamships at the large ports of the world has not kept pace with the increase in size of ships, even when allowance is made for the fact that commercial and financial conditions limit to a comparatively small figure the number of ports which need accommodate the largest vessels. The ports of this country have the advantage of such moderate ranges of tide level that they do not require such costly enclosed masonry docks, with locks, gates and operating machinery and other accessories, as are usually necessary at European ports. The vessels merely lie at piers or in open slips, and in such cases the deepening for larger vessels may perhaps be obtained simply by dredging. Even if reconstruction is necessary, it will, of course, be a much simpler and less expensive process than that of the reconstruction of masonry docks and their auxiliary works. At the same time, it must be borne in mind that several of the important ports of this country are admittedly defective in their capacity for accommodating shipping and for the handling and storage of freight. It is highly probable that within the next few years a considerable degree of attention will have to be given to this matter, both by the engineers of the port works and those of the railways having terminals at these ports. Among the improvements to be undertaken will be wider and deeper approach channels, better piers, better warehouses and railway facilities, and a wider introduction of methods for the mechanical handling and conveying of freight. At some of the ports on the Great Lakes, also, the present facilities are proving to be inadequate for the efficient and economical accommodation of the huge modern ore carriers and freight boats, so that there will be extensive revision and reconstruction of piers, wharves, river and harbor channels, etc. One other special feature to which reference may be made is that of dry-dock accommodation. There are at present throughout the world very few dry-docks capable of taking the largest ships afloat, whether naval or of the merchant marine. Besides the occasional docking for inspection and cleaning, the possibility of accidents has to be reckoned with, and it seems inevitable that the increasing number of large ships must lead to the construction of a number of dry-docks capable of accommodating these great vessels.

The use of the tee-rail for street railway tracks has for several years been advocated by the railway companies and their engineers, but for a long while there was a strong prejudice against them on the part of the public, and grooved rails for tracks in streets in the business district were in many cases demanded by the municipal authorities. At the present time, however, tee-rails are being extensively used in a number of large cities, and their use appears to be increasing. The railway engineer's views on the matter are well expressed in a paper which is printed in another column. The three forms of rail sections, or rail-head sections, used in this class of track are the tee-rail, the grooved rail and the side-bearing rail. The last is now little used in new work, owing to its numerous disadvantages; it requires the pavement between the rails of each track to be lower than that outside the rails, while its broad lower flange invites teamsters to keep on the track, thereby obstructing the cars. With both the tee-head and the grooved-head rails the paving is at a uniform level across the street, being broken only by the grooves for the flanges of the wheels. With the grooved-head rail, this groove is formed in a wide rail head, and the tread and guard together form a wide surface which like the step-rail or side-bearing rail tends to induce teamsters to follow the track. In a modification of this, known as the semi-grooved rail, the guard is lower than the head, so that while it protects the edge of the paving it prevents the rail from forming a wide surface for wagon wheels. In this country this form of rail is now more generally used than the grooved-rail proper, in which the head and guard are at the same level. The new standard rail of the street railways of the city of Mexico has a semi-grooved head, with a groove of such form and dimensions as to take the flange of the standard wheel of the Master Car Builders' Association, so that ordinary railway cars can be hauled over the street railway tracks. With the tee-rail, the comparatively narrow head is the only part exposed on the street surface, and wagons cannot well follow it. On the other hand, with this rail the inner side of the groove is formed by bricks or stone blocks (or slag blocks in Canada) laid against the gage side of the rail and having their edges beveled. Unless the groove is of proper form, the edges of the blocks or bricks are likely to be soon chipped or worn off by wagon wheels, causing a ragged and unsightly break in the pavement. This is a matter to which more attention might well be given, especially as the tee-rail seems to be coming more strongly into favor. While the grooved rail is much more generally used abroad, it must be remembered that the lighter classes of vehicles in foreign cities usually have wider tires than those of similar vehicles used in this country, so that there is less complaint due to wheels being caught in the groove and being broken (or having the rubber tires stripped off) when the driver tries to turn off the track. It must also be remembered that the street traffic is usually more closely regulated by the police authorities in foreign cities than in American cities, so that there is not so much liability of teamsters keeping on the track and blocking cars.

In considering the form and dimensions of the groove, one great difficulty which has developed in recent years is that of the size of the flange of the car wheel. For the ordinary street car, only a narrow and shallow groove is required, but with the introduction of interurban cars on city streets a larger groove becomes necessary to accommodate the heavier flange. This was pointed out in an editorial article in our issue of June 7. The groove must be deep enough to allow for the wear of rail head and wheel tread, and must have a flaring side to facilitate the throwing out of dirt and the turning out of street vehicles with narrow ties. At the same time the groove must not be so wide as to make an awkward break in the paving, or to admit the wider tires of heavy wagons, which would then soon chip off the edge and widen the groove. The use of the semi-grooved rail to protect the paving has been referred to above. The grooved-head rail is to a considerable extent preferable for city streets carrying the heaviest class of street traffic, which would soon wear away the edge of a groove formed in the paving and without the protection of a steel guard or edge. At sharp curves, track intersections, and special work in city streets, the grooved-head rail is particularly desirable, and it may also be used to advantage where the tracks cross boulevards or parkways and where it is desirable to interfere as little as possible with the surface of the boulevard paving. In the design of street railway rails and street railway track, the form of the rail head should be considered independently of that of the rail itself; for with any form of head, the height of rail or width of base can be adapted to the character of the traffic and the type of track support and paving. Thus in the case of the adoption of the tee-rail, an ordinary railway rail may be used in macadamized or unpaved streets, but for tracks in paved streets and carrying heavy traffic a deep or tee-girder rail is better in itself and better adapted to the paving construction. One other point needs to be mentioned, and that is the necessity of properly maintaining the pavement alongside the rails. Where deep ruts and holes are allowed to form along the side of the rail, as is not unfrequently the case, wheels and axles are extremely likely to be wrenched and broken, and the blame will probably be thrown upon the rail. A case recently came to our attention where an asphalt paved street had ruts 4 and 6 ins. deep and 12 to 30 ins. long, against the sides of heavy girder rails with grooved heads. The design was good, but the defects due to construction or to neglect of maintenance of the paving had led to the breaking of wheels and the overturning of wagons. These accidents, however, are in no way attributable to the form of rail or the form of the rail head, although the track probably receives the blame.

Garbage utilization by direct application to land under cultivation has been practiced systematically for many years in England, and also, though probably with less system and frequency, on the Continent of Europe. Similar methods have also been practiced in this country, but as a rule with far less regard for utilization than for a means of disposal with a minimum of nuisance and expense. As with sludge disposal on land, the universal experience with agricultural garbage disposal has been that after a few years the demand for the garbage on the part of farmers becomes less and less, until finally they can hardly be induced to make use of it on any terms. One of the greatest difficulties in the agricultural disposal of garbage is the large amount of foreign matter thereby introduced into the soil. Even where tin cans, bottles and other refuse are sorted out before the garbage goes to the fields, there is still likely to be an objectionable quantity of undecomposable matter. In addition, a considerable portion of the garbage itself is of such a character as to interfere more or less with the cultivation of the soil for a few months after the garbage is applied. To avoid the troubles due to the clogging of the land by garbage proper, a company in Paris, a few years ago, introduced a system of grinding the garbage and other refuse before delivering it for application to land. Elsewhere in this issue there will be found an account of some of the difficulties which the company has met. It appears that the ground garbage has piled up on the company's hands to such an extent that storage has become a serious problem. The city of Paris is now coming to the rescue of the company by making a new contract, under which incinerating plants will be built for the disposal of some of the refuse. From the information

at hand, it would appear that mixed refuse, instead of garbage alone, was taken to the grinding plants. If this was the case, it is not at all surprising that the demand for the ground refuse diminished after there had been a few years of experience with its application to land. There might be some soils, of course, that would be improved in texture by the addition of well disintegrated city refuse from which practically all glass, tins, etc., had been removed. But it will always be doubtful, in a given case, whether the cost of preparing and applying the refuse will not exceed any direct returns therefrom. There may be cases, however, where the problem of disposal, for one reason or another, is so difficult that application to the land will at least afford some economic relief; but in the most extreme case it is not unlikely that this will be a very large percentage of the total cost of disposal. Fertilizing values alone considered, there can be little doubt but that the best way to utilize garbage is by means of the reduction plants used on such a large scale in many American cities. Even here, the grease extracted from the garbage is far more valuable and more uniformly reliable than the fertilizer base afforded by the tankage.

Owners of boiler plants ordinarily look upon smoke prevention as a waste of money, which they do not voluntarily enter into. A different view is represented in the action of an English manufacturing company which designed and installed a smoke-washer in its boiler-house. The washer consists of a large brick chamber in which several sprays of water are disposed, through which the smoke is forced to pass on its way to the chimney; a flush-tank periodically flushes down the inclined floor of the chamber, washing the accumulated deposit toward a water-sealed outlet. Now, this device itself is perhaps not very costly, not costly enough to make it seem a surprising investment for a plant burning 310 tons of coal per week. But there is legitimate cause for surprise when we read of the water consumption of this smoke washer. The designers, who described the installation before the British Association for the Advancement of Science a few months ago, state that the sprays and the flushing-water amount to a total of 7,000 to 8,000 gals. per hr. For twelve hours this would be 90,000 gals., and for the whole day 180,000 gals. If the plant runs six days in the week, its coal-consumption per day is 116,000 lbs. If the figures refer to 12 hrs. daily operation, the smoke-washer uses ¾ gals. or about 5½ lbs. of water for each pound of coal burned in the boiler-furnaces; if 24-hr. operation, the consumption would be 11 lbs. per pound of coal. This is as much as the quantity of feed-water required. The cost of the washing-water, at 10 cts. per 1,000 gals. [a very low price when water must be bought], would be 0.0073 ct. per pound of coal on the basis of 12-hr. operation, and 0.0147 ct. on the basis of 24-hr. operation. With coal at $1.25 per ton [the plant in question burned a very low-grade coal], this would make the washing-water cost in the one case 15%, in the other 30%, of the fuel-cost! It is needless to add that so costly a scheme would be impracticable of application in a majority of cases. In spite of the fact that, as reported, it separated both dust and sulphurous acid perfectly. Local conditions, of which we have no knowledge, may very possibly furnish a very good reason why this particular plant was installed. Moreover, there is in England a very much stronger public sentiment [and a continuous agitation] for smoke-prevention than in the United States, and this may have been influential in the case. This stronger public sentiment we must envy, for it does not require, to demonstrate the evil of the smoke nuisance, such reports as one that appeared in the newspapers a few days ago: that a herd of cows which died under mysterious circumstances was probably killed by the effects of heavy smoke from a nearby steam-shovel, accumulations of soot having been found in the stomachs of the animals on post-mortem examination!

FACTORS OF SAFETY.

In every engineering construction, much more material is used than is necessary to provide the desired strength. This excess material furnishes the so-called "factor of safety" of the construction. It is *unutilized material*, and in one sense, therefore, may be called wasted material; in amount it is always *more than the utilized material*. As follows directly from the last statement, it is easier to save material by reducing the unutilized than the utilized portion; and, conversely, it is easier to waste material in the factor of safety than in the loads or stresses.

Almost the entire field of engineering construction and research is devoted to the study of strengths, capacities and the like, in an effort to adapt material to various needs most economically. All of this study concerns itself with the utilized fraction; none with the idle or unutilized material. But the very amount of the latter gives it an importance at least equal to the other. In other words, it is just as important that we should have definite ideas on this fraction as on the utilized fraction. Yet it will be found that only rarely does the individual engineer hold very clear ideas on the subject of factors of safety; he is content to follow traditional and conventional methods with little inquiry. It is true, of course, that in many quarters the subject is thoroughly well understood, and doubtless it has repeatedly been discussed in all its bearings; nevertheless, since definite understanding of it is not universal, or even general, it may be profitable here to review some phases of it in brief.

We remark in passing that the use of factors of safety is not restricted to the matter of strength, but extends also to most of the other governing conditions of design, as capacity for a given traffic or service, or, more generally, adequacy for the desired purpose. Overload capacity, reserve power of any kind, so-called "insensibility to abuse" in a machine, all are instances of the application of factors of safety. But for various reasons the matter of strength is so much the most important application, and in its details it is so distinct from the others, that our attention here is restricted to this one subject.

It is erroneous and even dangerous to assume that there is only *theoretical* importance in the study of factors of safety. A single instance will illustrate this: It is well known that design generally bases on certain so-called safe or working stresses in the material. Generally, if this working stress is 1/Nth part of the failure or crippling stress of the piece, the factor of safety is said to be N. It happens in many (if not in most) cases that when the stress in the material is 1/Nth of the crippling stress, then also the load is 1/Nth of the crippling load. But not always is this the case: A loaded reinforced-concrete beam may have, in one of its elements, a maximum stress which is one-fourth of the crippling stress for that element, but the ratio between actual load and crippling load may be quite different from one-fourth; instead it may be one-third or even one-half. Thus, while it might be hastily assumed that the beam is taxed to only one-fourth its capacity, yet when we consider the load, the attack of external forces, we find that these can be increased only by the factor two before failure occurs. In such a case, inconsiderate talk of a factor of safety of four is positively misleading; at the same time, the factor is undoubtedly greater than two.

A careless confusion of margins of safety on loads and on stresses, respectively, is indeed the principal reason for the necessity of full and cautious discussion of factors of safety. An associated reason, important in itself, is the complexity of the safety-factor; for, while the name implies a definite single conception, a factor of safety is far from being a single thing. It is a composite; its reasons and services involve a variety of elements. This is almost at once apparent, if we remember the alternative names that have often been used for factor of safety: it has been called "Factor of Uncertainty" and "Factor of Ignorance"; very properly, too, because it is based in part on the uncertainty of the several conditions that affect a construction, and in part on our ignorance of the true conditions, even though these be certain and definite in themselves. It will be conceded without further reflection that there is more than one thing about a design and its service that is uncertain, or that we do not fully know; and as the factor of safety must cover all of the elements that are unknown or uncertain, or contingent on possibilities, its composite character at once appears.

The preceding explanation refers to the engineer's or the designer's interpretation of the term "factor of safety." To him the term applies to the margin between immediate danger of failure and the actual condition of the structure as designs. The use of the term by the layman, while it might be defined in almost the same words, is yet quite different; he calls "factor of safety" the ratio between the failure load and the maximum working load, or the number of times that the working load could be multiplied before the structure would fail. This evidently is a much simpler view; yet, even in this view, the term is complex. If the structure in question were exposed to but a single quiescent load and to no other attacking forces, then direct multiplication of this load to the point of failure would, it is true, establish a definite, single-valued factor of safety. Few structures have such simple service; most structures are designed for (and actually exposed to) distributed loads and concentrated loads, quiescent and moving loads, shock, wear, corrosion, freezing, and other forces of attack, each of which may be destructive independently of the others. Which shall fix the factor of safety? Some of these forces are not even subject to definite measurement, so that it would be meaningless to say that they can be multiplied N times before they produce failure. The layman's use of the term is generally applied to the most common form of loading or attack; in securing simplicity by this means, however, all claim to accuracy is sacrificed. As a matter of fact, except in a restricted range of simple cases, "factor of safety" is not properly a layman's term at all, but should be used only by the engineer and for the engineer's purposes.

Any attempt to subdivide or analyze the elements of factors of safety must take account of three separate sources of uncertainty. These are (a) the Material, (b) the Structure, or the composition of the material, and (c) the Loads, or the attack in service.

The first of these, the Material, involves uncertainty in a variety of ways. The material is not uniform, either from point to point in a given piece or from one piece to another; nor is its range of variation of properties definitely fixed or thoroughly known. In some cases the material is not permanent, variations in its properties occurring in the mere lapse of time without any clear external influence. Under these conditions, our knowledge of the strength of the material, as drawn from tests, is at best only an approximation and requires the application of a large margin before we can feel secure. Nor are our tests directly correlated with the action of material in service form, even aside from these uncertainties; since tests are made on pieces of small size, under special conditions, by "accelerated" methods, etc. Some of the differences between test and service stresses are known, but many of them are either quite unknown or so variable that they are not susceptible of detailed study.

These uncertainties in the item of Material require an allowance which is most conveniently expressed in the same terms as the known properties; that is to say, in terms of the unit stress. By test we determine the unit resistance of the material; for use in designing we arrive at a safe or working unit stress by allowing a suitable margin of safety on the failure or crippling stress. The magnitude of the allowance depends, of course, primarily on the magnitude of the several uncertainties involved, but in some degree it depends also on one or two *qualitative* factors. With the same degree of uncertainty, for instance, a ductile or malleable material, like soft steel or iron, would generally be given less margin than a brittle material; highly homogeneous character (as against danger of localized fail-

ure, development of flaws, etc.) also favors a smaller factor of safety; and in some materials there may be a self-healing quality which makes it of less moment whether we approach or perhaps even exceed the failure-point of the material.

The second element, the Structure, does not involve any question of suitability of design; for our purposes, the latter is presupposed. But the inaccuracies and approximations of stress-analysis do concern us under this heading. Secondary stresses, in so far as they cannot be (or are not) computed, are also sources of uncertainty due to the structure as such. Further, the structure as commercially made may vary from the proper form and disposition of the parts as presupposed in the design and as striven for in the manufacture; this may cause the strength of the structure or the efficiency of its resisting elements to be affected, and calls for an empirical allowance [the departure of a column from straightness, and the inaccuracy of gear teeth, are examples of this]. Most of the elements that define the difference between a design and the actual execution, or between a "paper design" and a working design, are referable to this heading of structure. On consideration of the items here scheduled, it will be recognized that some of them increase or decrease the external forces and are therefore to be allowed for on the loads, while others affect the resisting power of the material and are appropriately included in the margin allowed on stress. Still others may not be easily provided for in either the loads or the stresses, but can in practice be disposed of by adding to the amount of material called for by the computations.

Somewhat related to structure but in part connected with the service of the construction are certain other items, for example: the flexibility or rigidity of the construction; the degree in which it is exposed to incidental damage either when in service or during other handling; and the concealed or exposed condition of parts, as promoting hidden deterioration or concealing the growth of defects from observation. These are met either as above noted, or they may take rank with certain other considerations of more general bearing that are noted a little farther on.

The third heading, Loads, or the attack of external forces, involves, besides the direct intended loading: The possibility of extraordinary loading; the probability of increased regular loading in the future; and such modifying elements as vibration effect, impact, resonance, repeated stress, and the like. All these involve unknown or contingent effects, and are therefore necessarily the subject of a safety-allowance. From the standpoint of the designer, such allowance should be made in the loads which form the basis of the design, since the effects in question act as intensified attack of the loads. After determining the actual weights which the design must withstand or uphold, the designer must multiply these weights by a proper "factor of load," to obtain an effective or equivalent loading which shall cover the uncertainties and the secondary effects referred to.

Most of the other items which are to be classed under attack of external forces depend, for the kind and amount of provision made to meet them, mainly upon the circumstances of the individual case. Such are, for example, the deteriorating influence of corrosion, weather, mechanical and chemical disintegration, cracking, freezing, the effects of settlement, and so on. Some of these affect the details of design, that is to say they modify the form of structure used. Some, as settlement, may need to be computed as Loads in one case (as in a continuous-girder bridge) and in other cases (as in an engine foundation) are dealt with by empirical increase of material.

There is a further group of considerations, general in character, which influence the proper value of the safety-allowance in a structure. They are unlike the considerations of Material, Structure and External Forces, and may be said to be auxiliary to them, inasmuch as they do not directly represent uncertainties or contingencies. Their application lies in modifying the importance of the uncertainties affecting a specific structure. For example, if a structure happens to be in a location or in a class of service where its failure would cause great damage, it is manifestly proper to give that structure a larger margin of safety than is required for one whose failure would do little damage. Again, if the cost of increasing the safety-factor is very considerable (in relation to either total cost or available funds), then it is justifiable to take a longer chance, to use a lower factor of safety, than if the cost of increase were insignificant. Of such general considerations we may note, (1) and (2) the amount of damage or loss which failure would produce, and the relative cost of increasing the factor of safety [as just instanced]; (3) the type of failure of the construction in question, whether sudden or gradual; (4) the kind of deterioration to which the parts of the structure are subject, as affecting the possibility of unsuspected weakening and failure without warning; (5) the closeness of inspection and promptness of repair; (6) the ease or difficulty of renewal.

While these considerations are of vital importance in the economics of design, yet they are not involved in the question of *classification*, which, as we earlier point out, is the chief source of misunderstanding and confusion in the matter of factors of safety. For, while some of them operate to reduce or increase the factor of safety on loads and others to reduce or increase the factor allowed on stresses, yet they are so directly connected with the loads and stresses, respectively, that no mistake is liable to result on this score.

In the practical work of fixing a factor of safety for the design of a given structure, the order of procedure will generally be just the reverse of the order in which the several elements have been mentioned above. It will be the designer's first duty to estimate the cost of failure, the cost of increased safety, and the like, arriving thereby at a general idea of the magnitude of the allowances to be made. This is the General Factor. He then measures and analyzes the forces to be provided for; calculates, in so far as possible, their secondary effects and other contingencies, and finally allows on the loads thus defined a Factor of Load to cover the uncertainties of the estimate. He then arranges and analyzes the structure, selects the material, and proportions it on the basis of its strength reduced by a Factor of Stress selected to cover the uncertainties of the material. [As already noted, the uncertainties of stress-analysis are here included, while other contingencies of the structure are to be covered partly by the factor of stress and partly by the factor of load.] Finally, the designer estimates the permanence of his construction, and various accessory elements (such as desired stiffness and resistance to accidental damage), and allows on the dimensions and thicknesses previously fixed a Factor of Protection. The result of his work will not give the structure any definite factor of safety, but it will make the design safe.

LETTERS TO THE EDITOR.

Notes and Queries.

Referring to some remarks in a recent issue of Engineering News, Mr. E. R. Scammell, Secretary of the Powell Wood-Process Syndicate, Limited, Temple Bar House, 28 Fleet St., London, E. C., England, writes us as follows:

FIRE-KILLED TIMBER.—We see by your issue of Aug. 2, under the above heading, that you make a reference to spruce, stating that it resists mechanical wear but needs a preservative treatment to make it resist decay. You are doubtless fully aware of the fact that it is impossible to creosote this wood, except in very small pieces and under great pressure, so that, notwithstanding its suitability, it has been very little used for paving purposes. We find this wood most amenable to our process, and after treatment it makes ideal paving, as, owing to the silkiness and length of the fiber, the surface of the wood burrs, making a homogeneous pavement. Sections have been laid in London and elsewhere, and the results are most gratifying.

Prof. A. Black, author of the article, "Comparative Tests of Cement Mortar, Showing the Relative Effect of Three Different Sands," published in our last issue, Aug. 30, p. 236, is Adjunct Professor of Civil Engineering, Columbia University, N. Y., instead of Instructor in Civil Engineering, as given under the article in question.

Methods Used in Running Long Railway Tangents.

Sir: I have noted the letters in recent issues with regard to the length of railroad tangents. I think it would be interesting to have some information regarding the methods used in running tangents. Have special methods or care been taken to have them straight? The question is of considerable importance to me at present, and I would be glad to have any information your readers can give.

Yours truly,

A. B.

New York, Aug. 27, 1906.

The Longest (?) Railway Curve.

Sir: Noting that some of your readers are interested in information as to long railway curves and tangents, I will state that on the Central of Georgia Ry. [completed in 1843] there is the longest and flattest curve of which I have ever seen any record. This curve commences at a point eleven or twelve miles from Savannah, and is 26,500 ft. in length. This radius is 150,000 ft., the degree of curvature being about 2⅓ minutes. The central angle is about 10 degrees. As originally located and graded it was about six miles long, but the location was changed and about one mile of it abandoned. It is not a compound curve.

On the same railway there is a curve 7,139 ft. long with a radius of 16,000 ft., and one 8,374 ft. long, with a radius of 20,000 ft.

Yours truly,

Arthur Pew.

Atlanta, Ga., Aug. 23, 1906.

Designing by Working Stresses or by Factor of Safety Applied to Ultimate Values.

Sir: I have been interested in the controversy as to whether ultimate or safe values should be used for steel and concrete in designing reinforced beams. The following reasons have been given for using safe limits:

(1) That if the desired safe resisting moment be multiplied by the factor of safety and the beam designed by using ultimate values the result is a beam in which under its "safe" working load the concrete may actually be under more than its safe compressive stress or the steel under more than its safe tensile stress; in other words, the factor of safety in either steel or concrete may be more or less than the desired factor.

(2) That architects and engineers often specify that under working loads neither the steel or concrete shall be stressed beyond certain given limits, consequently it is desirable that those limits should be used in formulas, rather than ultimate strengths.

A beam, unless for experimental purposes, is intended to carry a certain safe load, not to fail under an ultimate load, and if certain limits are assumed as safe for tension in steel and compression in concrete, then surely what is desired is a beam in which, under the working load, both the steel and concrete will be stressed exactly to those limits, and the proper formulas are those which use those limits.

Also, in locating the neutral axis we are not interested in how it may rise or fall immediately before failure, but only in its position under the safe load, which is not by any means its position under excessive loads, consequently formulas used for locating it should be based on the safe stresses in steel or concrete.

The only reasons given for using ultimate values so far as the writer has seen are (1) that it has been customary in designing—presumably meaning in designing steel or wooden beams, and (2) that it amounts to the same thing in the end, which is not literally true.

Yours truly,

John S. Ely.

Philadelphia, Pa., Aug 29, 1906.

The Design of Reinforced Beams and Slabs.

Sir: I beg once more to use the columns of your paper to reply to the long and interesting letter of Mr. Godfrey, published in your issue of August 23. In this letter Mr. Godfrey repeats good and useful principles well known by all proper designers in reinforced concrete as well as by the writer. It is very old matter that theory and practice must go hand in hand, that rods for reinforcement should be embedded a given number of diameters to develop their full strength and that the proper design of a slab and beam demands that the steel be well distributed and in small rods rather than being concentrated in elements of large diameters. But repeating these principles Mr. Godfrey does not say that he maintains again his rules in their full conclusion as they are printed in your issues and with which the writer does not agree. These principles are (issue of March 15, pp. 291, 292):

(1) The rod should be no more than $\frac{1}{200}$ of the span.

(2) The maximum depth of a beam is 20 times the diameter of the rod embedded or $\frac{1}{10}$ of the span. The maximum depth should be used only in extreme cases.

In your issue of July 12, p. 30, Mr. Godfrey says that by his rules it becomes a simple matter to design beams and slabs in this comparatively new combination of material, which is to say that design will be much easier than it was till now. This is not the writer's belief. The examples given by the writer in his first letter (August 2) were only to show to what design these rules may lead if the designer follow them literally. Good designers who know their business will in the most cases not follow these rules as their own author has done in his example cited. For poor designers who overlook the fundamental principles stated above and who do not know much about reinforced concrete, rules as these given by Mr. Godfrey may become a danger and make them advance from bad to worse. Just because, as says Mr. Godfrey himself, this kind of construction is in its infancy, the writer's belief is that it will be a guess matter to give now rules to govern the proper proportioning of the steel and the limiting length of the span, *etc.* Nevertheless, papers as these of Mr. Godfrey are very useful and interesting.

One point which seems to me to be overlooked by Mr. Godfrey is the fact that reinforced slabs and beams are in the most cases designed as continuous elements and the rods of one slab or beam overlap the rods of the next, and then the length of the rod embedded in concrete exceeds in many cases the length required by the calculation though the diameter be larger than $1/200$ of the span.

Mr. Godfrey criticises the writer's example with a beam of a span of 6 ft., saying that a slab should be in order for this span. I would answer that beams at a span of 6 ft. or less are often to be designed over openings and have sometimes to carry large concentrated loads which a slab would not do.

As to my so-called (by Mr. Godfrey) dogmatic assertions about the failure of well designed beams, overlooking laboratory tests with small elements, I would refer Mr. Godfrey to the text-books of Christophe, p. 490 (French text) and of Prof. Mörsch, "Der Betoneisenbau," p. 121, etc., where the failure of beams is discussed, and he will see that it is not only my own judgment. The finished building test by Mr. Godfrey in which beams have failed by shear under the test load (generally 1½ to 2 times the live load for which the floors are designed) should be of a very poor design and for this reason cannot be cited as reference. The writer has had the opportunity to assist in tests made in France (Paris) and in Germany (Charlottenburg, near Berlin), and he himself has made many tests on large elements and got other results than those cited by Mr. Godfrey. The writer believes that deep beams designed only for the bending moment will fail by shear as well as beams of a small height will do when they have to carry a concentrated load near the supports and the reinforcement was not designed for the purpose.

To substantiate the assertion that in large beam longitudinal cracks occur in the spaces between the rods, the writer would say that an analogous fact occurs in slabs reinforced in one way and to avoid these cracks additional cross-rods are embedded. In some large beams the writer has himself verified these cracks in cases in which special arrangements, as little cross-bars or special U-shaped stirrups going under all rods were not provided.

As to the steel area to be used the writer knows that sometimes beams are designed with a steel area of 2% or more and his idea was not so much to criticise this amount, as to give a suggestion that when speaking about the cost the amount of concrete be given in cubic feet and the steel in pounds per lineal foot of beam or per square foot of slab.

Very truly yours,

M. Morssen.

38 West 26th St., New York, N. Y., Aug. 26, 1906.

Rolled Maps or Separate Sheets for Use in Railway Location.

Sir: Replying to your correspondent, Mr. D. M. Fraser [Eng. News, Aug. 23, 1906], in regard to the merits of rolled maps and separate sheets for the detailed maps of railroad location, it may be pointed out that, although separate sheets were advocated by Mr. Wellington, their use has found very little favor among American engineers. Mr. Fraser can hardly claim a monopoly for the small scale map for the determination of the general route, as this is common practice in the West where up-to-date methods are used, and was described by the writer in a paper read before the American Society of Civil Engineers in January, 1905 [Trans. Am. Soc. C. E., Vol. LIV., p. 104], on "Methods of Location on the Choctaw, Oklahoma & Gulf R. R."

The arguments for or against separate sheets or rolled maps are confined to those affecting their use for maps to be used for the purpose of working out the details of the location. It is generally conceded now that a topographic map should be made and the location projected on it, and really the only argument in favor of separate sheets is an impression that, by their use, this topographic map can be produced more cheaply than it could on a long roll. It is argued that by using the separate sheets they may be taken into the field and the topography platted directly on them there, whereas, by any other means the notes only are taken in the field and then have to be transferred to, or platted on, the roll map in the office.

The fallacy of this is evident when we consider that to plot the topography on the separate sheets in the field requires three men. If the same topography be taken and sketched in a note book ruled in squares, similar to cross-section paper, two men can do the work, and it only remains to transfer this to the map in the office. The field draftsman can do this in about two hours, so there is the actual saving of one man's time, as the field draftsman is necessary in any event.

Of course, the amount of topography to be taken does not enter into the argument at all, as whether this will be little or much depends on the topographer and the ideas of the locator; but to get the same amount of topography will always cost less by the note book method than by the separate sheet method; this the writer has proven by actual experience.

There can be no argument that the separate sheets lay flatter than a roll map, as a long 36-in. roll will lay flat for that portion of it on the table.

There is a further argument in favor of using a note book rather than the separate sheets, inasmuch as by doing so work can be carried on in the field in damp weather or even a light rain when it would be impossible to use the sheets. Possibly Mr. Fraser's experience has been confined to that part of Australia which has a particularly dry climate most of the year, so that he little appreciates the climatic conditions under which location surveys have to be carried on in the larger portion of the United States.

The space of a letter to the editor is too limited to go into the arguments for and against taking much or little topography, but the argument that the topographer should take only barely sufficient for the projection of the location presupposes that the topographer knows as much before he takes the topography as the locating engineer does after he has completed his studies covering the whole situation and eliminated everything but "the best line the country affords;" a few extra contours cost very little, provided proper methods are used, and there is an infinite satisfaction to the locating engineer when he comes to project the location in having *everything* on the map before him which may in any way affect the location.

The rarity of common sense is easy to admit; practical locating engineers also know that the general run of men found in a locating party, to whom the duties of taking topography fall, are not fitted by either training or experience to form accurate judgment as to the possibilities of the location, and the question resolves itself into whether a highly trained man should be engaged to take a little topography, or perhaps two men at an aggregate lesser salary to get *all* the topography which may possibly be used, leaving for the locating engineer the privilege of being the man who exercises the judgment as to what he wants to use. In any event, the man who is in the field gazing at a big patch of briers is apt to have his judgment badly warped, and he might possibly warp the line at that point.

The whole point of Mr. Fraser's argument is probably contained in the words "adopted preliminary" in the first paragraph of his letter; this is our old friend, the "preliminary location." Modern American practice has abandoned this, and while relying on the quality of the reconnaissance to determine a general route, and confine the *preliminary survey* within reasonable limits, this latter is really and properly only a survey which, it is intended, shall develop the country, and be the means to the end of producing the map on which the location will be finally projected and laid out, by balancing the various factors which affect it, as well as the judgment of the locating engineer will permit.

Yours very truly,

F. Lavis.

42 South 10th Ave., Mt. Vernon, N. Y., Aug. 27, 1906.

The Country Surveyor and the Impertinently Curious.

Sir: Why is it that the majority of people consider the business of the surveyor to be public business, and how is the surveyor, working in the public highways and in the market places, to answer or ignore the questions of the impertinently curious without giving offense?

At first sight this query may seem to be facetious and flippant, but the problem is of no mean importance to a large class of practitioners, and doubtless the views of some of their professional brethren would be of interest. The matter is of no import to those engineers engaged on large construction works, for two reasons: (1) Everyone is aware of the nature of the work, because of its magnitude and because it is usually of a public or semi-public nature; (2) those employed on such a job are in no way dependent on the good will of the spectators, and so may answer questions in such manner as they see fit, or not answer at all. The class on whom the burden does fall consists of the lesser lights of the [illegible] the country surveyors who depend upon the [illegible] of the members of the community in which [illegible] and labor.

The nuisance is especially great when the [illegible] at work on a road just outside the limits [illegible] village to and from which the inhabitants [illegible] rounding country are continually going and [illegible] day's work in such a place, uninterrupted by [illegible] is an impossibility, and the number of inqui[illegible] what is being done often runs well into two fi[illegible] stop and explain what you are doing, why you [illegible] it and for whom you are doing it, wastes many [illegible] minutes; moreover, there are not infrequently [illegible] reasons why it is inadvisable to impart th[illegible] information. In the latter case, what is to [illegible] Self-interest, if not courtesy, precludes the [illegible] it is none of the questioner's business, alth[illegible] temptation to make such retort is ever presen[illegible] Your interrogator may be an acquaintance whom yo[illegible] wish to offend, or he may be a future patron. A [illegible] surveyor having a general practice never kno[illegible] whom his next job may come, and if he gives [illegible] impertinent questioner the sharp answer that he [illegible] deserves, and if that same person later requ[illegible] the services of an engineer, the chances are that, [illegible] he has the choice of two or more engineers, he [illegible] employ the one who rebuked his curiosity.

Suppose that an engineer is engaged to make a [illegible] and that his employers, for reasons of their own, stipulate that he shall not make public the nature of his work nor the names of his employers. Suppose, also, that the work has to be done in a public place and that it is of such a character as to stimulate inquisitiveness. And, finally, suppose that some one, whom the engineer cannot afford to offend, asks him point blank what he is doing. What shall he say? Obviously he cannot give the desired information. He has, then, four choices: (1) He may ignore the question, (2) he may evade it, (3) he may flatly refuse to answer, giving no reasons for his refusal, or (4) he may decline to answer and explain the situation. There are serious objections to all of these measures. The last course, while it may not give offense, takes too much time and is inexpedient as well. The other three are almost sure to anger the questioner, and the first two are difficult. Whatever he does, unless he is blessed with an extraordinary amount of tact, he is certain to affront many people and bring down upon his head the wrath engendered by unsatisfied curiosity.

The citation of an actual case similar to the supposititious one just stated may serve to illustrate the trying position in which the engineer is often placed. An engineer in a large New England manufacturing town was engaged by a committee of prominent men of the town to prepare a map of a certain business section in the heart of the village. The map was to be used in court, and for the best of reasons it was imperative that the work should be done quietly and, if possible, accomplished without the knowledge of those on the other side of the case, hence secrecy was enjoined upon the engineer. One day while he was busy on the field work an influential business man, a high official in one of the town's important manufacturing concerns, notorious for its dislike of publicity, drove up to the engineer and with all the arrogant assurance peculiar to the provincial "leading citizen" inquired, "What are you surveying here, ——?" The engineer had heard the same question in various forms many times that day, and now, exasperated and at the end of his patience, replied, without raising his eyes from his note book, "How is your business to-day, Mr. ——?" Needless to say, the ire of the inquisitive gentleman was aroused, and he drove away in resentful silence. Although he was an old acquaintance of the engineer, he refused to speak to him for some time after this encounter, and no doubt was instrumental in placing certain commissions in the hands of other engineers.

Without doubt the rebuke administered by this sufferer was hasty, ill-advised and impolitic, but when one is harassed and interrupted by such questions, not once, but many times a day, it is small wonder if he loses his temper and forgets to give the soft answer that turneth away wrath. The worm will turn; and after several hours' labor in the hot sun, wearied by the eternal vigilance necessary to the use of green or inefficient helpers, and badgered by impertinent questions and all the clumsy and tiresome attempts at humor that every passing yokel feels called upon to perpetrate, it is strange that the long-suffering and patient chief finally turns on his persecutors and answers with a sharpness and acerbity that may work him evil in the future.

Any solution of this problem that may be offered, by which an engineer can remain at peace with the passer-by and possible patron, preserve his temper, do his work without undue interruption, and when necessary keep his and his employer's affairs from the prying of the curious, will be welcomed by many of the afflicted ones struggling with this vexing question.

New England, Aug. 30, 1906. T. H.

On Proportioning the Reinforcement of Concrete Columns.

Sir: In your issue of July 12, 1906, Mr. Edward Godfrey treats at some length the question of design of reinforced concrete columns, and develops formulas for proportioning the reinforcement based upon the theory that the concrete at failure becomes a granular mass, whose lateral pressure is 1 divided by 4.8 times that of a liquid confined in a cylinder. He arrives at the conclusion that in a circular column of diameter D the spiral reinforcement should be a square rod, whose side is equal to $\frac{1}{10}$ the pitch of the coil equal to $\frac{1}{8}$ D, and the longitudinal reinforcement 8 square rods of the same dimensions as the spiral.

It seems to the writer that your correspondent in his fundamental assumptions and deductions therefrom has been taking a "long shot."

The relation between the lateral and the longitudinal pressure of a granular mass confined in a cylinder and subjected to its own weight or to additional pressure, bears very little resemblance to that of a fluid under similar conditions, for the following reasons: In treating a confined granular mass we are dealing with a substance in which there is an appreciable friction between the particles of its own mass, as well as a friction between these and the walls of the confining cylinder. This is obvious, for one has only to consider that a bucket full of sand thrown out upon a board does not spread out to a uniform depth, but remains in a more or less cone-shaped pile, neither will it slide from the board until the latter is tilted to a considerable angle. Owing to these physical facts, when a granular mass is confined in a cylinder its weight is supported partially by the bottom of the cylinder and partially by the sides acting as a column, while the sides are at the same time under tension due to the lateral pressure.

This action of granular masses confined in bins, and the relation of lateral to longitudinal pressure, have been very thoroughly investigated by Mr. J. A. Jamieson, of Montreal, and made the subject of a very complete paper presented before the Canadian Society of Civil Engineers, and later published by Engineering News (March 10, 1904). Mr. Jamieson found, for such granular masses as wheat, corn, flaxseed, etc., that when no settlement of the bin walls occurred, approximately only 20% of the confined mass was supported by the bottom of the bin, while the remaining 80% was supported by the sides acting as a column; that the lateral (maximum) pressure at any point was practically constant and equal to $^{6}/_{10}$ of the vertical pressure when the height of the grain column was equal to or exceeded about 4 times the diameter of the base; also that it made little or no difference in these relations if the bin was round or square. Among many experiments recorded by Mr. Jamieson was one on dry sand, and it is interesting to note that he found approximately the same results as for wheat; that is, a ratio of lateral to vertical pressure of 0.65, and 81.5% of the total weight carried by the sides of the bin.

A very simple experiment in line with the above may be performed by making a tube, say 10 ins. long and 2 ins. in diameter, from thin writing paper, placing it on end and filling it with dry sand. When the sand within is subjected to pressure, the first noticeable feature is a buckling of the walls of the tube, generally about $\frac{1}{3}$ the height up from the bottom. Additional pressure causes rupture, the resulting tear running parallel to the long axis of the tube. If the length of the tube be made 20 ins., the diameter remaining the same, and the sand subjected to pressure, there is a buckling of the walls of the tube followed by a bending of the whole and a failure near the center, the tear in this case being at right angles to the long axis. In the first instance the walls acted as a column until they failed (buckled), then ruptured under a tensile stress such as would be caused by hydraulic pressure. In the second instance the walls failed by buckling, then ruptured under the stress caused by the bending moment at the center.

Sand confined in a cylinder can be made to withstand enormous loads, limited only by the strength of the confining cylinder. This is the principle of sand wedges used in arch construction, and is well known.

If we are going to treat the reinforced concrete column at rupture as so much disintegrated matter or as sand, and from this assumption develop formulas for ascertaining the dimension of steel spirals to withstand this disintegrating action, then there are more and different factors to be considered than those used by Mr. Godfrey. In view of Mr. Jamieson's experiments, quoted above, the lateral pressure would be 0.60 of the longitudinal and not 0.21 (i. e. 1 ÷ 4.8) as stated by your correspondent. That is, the lateral pressure is about three times as great as he assumes. The matter of the walls (spirals) carrying 80% of the loading as a column is not taken into consideration by him at all, and it seems to the writer that it is radically wrong to apply to a concrete column this theory of disintegration which logically demands that the walls (or longitudinal reinforcement) take 80% of the imposed loading. To follow up this line of reasoning must reduce one to dispense with the concrete altogether and employ an all-steel column.

A mild steel rod in the form of a coil is metal not well disposed to act as a column carrying loads, and experiments on reinforced columns in which the reinforcing is only spirals or hoops show a much larger degree of compressibility under loading than columns in which longitudinal rods of considerable size are employed. This is well brought out in Mr. Howard's article in the issue of Engineering News for July, 1906, in which he says "Hooped columns are a distinct group and decidedly more compressible than the others." In the same article it is clearly shown that hooping a column of 1-2-4 concrete will add greatly to its ultimate strength, and so will the addition of a fair amount of longitudinal metal (2.86%), while a combination of the two will further increase the ultimate resistance under loading. A mixture rich in cement and unreinforced (1 of cement to 1 of sand) is 20% stronger than a 1-2-4 concrete reinforced with 25 hoops and 4 angles, and considerably more rigid under loading. In these tests on 1-2-4 rock concrete the hoops were 1½ ins. wide by ⅛-in. (given as 0.12 in.) thick spaced at various intervals. The smallest recorded number (13) increased the strength of the column 58% above that of the plain unreinforced piece, while the largest number (47) increased the strength 274%, raising it to 5,289 lbs. per sq. in. In the latter case the spacing of the hoops was a trifle over 2½ ins., or the neat opening between the hoops was 0.66 times the width of one hoop. Mr. Godfrey's deductions that the diameter of the square spiral rod should be $\frac{1}{40}$ D, spaced ⅛ D, leaves a clear opening of $\frac{1}{10}$ D between the rods, which opening is four times the width of the rod. This does not look like metal well placed to confine a disintegrating mass.

In a reinforced beam we place the metal where it will resist the tensile stresses, leaving the plain unreinforced concrete to take care of the compressive stresses of 500 lbs. per sq. in. or greater. If this is good practice (and it is a common one) why should we design a column on a basis of 550 lbs. per sq. in. of compressive stress and then reinforce it. In other words, unless we either figure upon an allowable unit of compressive stress of much greater amount than 550 lbs., or assume that the longitudinal reinforcement carries a portion of the imposed load, then we have not reduced the size of the column under that of one not reinforced, and have added largely to its cost. It is the large size of columns (compared with steel) that in actual practice makes them so objectionable to many architects. This size can be reduced to reasonable limits by using a concrete mixture rich in cement, reinforced with spirals or hoops that form a close enclosing mesh and longitudinals to which they are firmly attached, assigning to the concrete a high compressive unit of resistance and to the longitudinals a portion of the imposed load, but not by the formulae and method suggested by your correspondent.

Very truly yours,

G. B. Ashcroft,
C. E. Assoc. M. Can. Soc. C. E.,
Supt. Roman Stone Co., Ltd.

Toronto, Ont., Aug. 17, 1906.

The Design and the Behavior of Reinforced Concrete Columns.

Sir: I have before me proof of Mr. G. B. Ashcroft's letter in which he objects to my method of proportioning a reinforced concrete column, and thank you for the opportunity to reply to the same. The answers to Mr. Ashcroft's objections are found partially in the papers which he cites and partially in his own letter.

I have always considered the paper by Mr. J. A. Jamieson on tests on grain bins as a very valuable contribution to engineering knowledge. These tests were made to determine the relation between the head of grain in a bin and the horizontal and vertical pressures in the grain, and were not made with a view of finding the bursting pressure of a confining cylinder which has no longitudinal strength. One experiment made by Mr. Jamieson on a cloth cylinder showed what one naturally would suppose, namely, that if the walls can yield vertically the grain itself will support all of the weight. In a steel cylinder a large part of the weight would be carried by the shell. A coil in a reinforced concrete column would act like the cloth cylinder; that is, it would take none of the load on the column. Unfortunately for column investigators, Mr. Jamieson did not measure the lateral pressure on the cloth cylinder. However, among his experiments there is one which has a direct bearing on this subject. The experiment referred to is one in which a bin having sides that could be raised and lowered was filled. The pressures on the bottom and sides were measured, and the latter was found to be about six-tenths of the former, as stated by Mr. Ashcroft. Upon lowering the sides all of the grain as well as the sides themselves was supported on the bottom. Mr. Jamieson says [Eng. News, March 10, 1904, p. 238]:

> On the bin being again lowered to its original position, while no increase of lateral pressure was shown by the side diaphragm, there was a very large increase of pressure on the bottom diaphragm, or sufficient to cause the water to flow out of the top of the 4-ft. gage glass tube, which was not therefore long enough to record the pressure; in fact, the total weight of the grain was then resting on the bottom diaphragm, and in addition the grain was acting as a column to support the weight of the bin itself.

Now the lateral pressure in this experiment at the bottom of a bin 78 ins. high was .1894 lb. per sq. in. This is only one-twelfth of the vertical pressure instead of being six-tenths.

In one of the experiments referred to by Mr. Ashcroft, among those made at Watertown Arsenal, is one on a column reinforced with wide bands. By my count these bands come within a half inch of each other instead of an inch. This column stood 5,289 lbs. per sq. in. It is safe to say that the concrete was in a state bordering on disintegration under this load. The lateral pressure on the bands could not have exceeded a force that would stress the steel to its ultimate strength, and this will give us a basis for determining that pressure. In the 2 ins. of a 10-in. column occupied by one band an equivalent fluid pressure would be $2 \times 5 \times 5{,}289 = 52{,}890$ lbs. If the net area of the band were an eighth of a square inch, the unit tension on the basis of a liquid pressure would be 423,000 lbs. I do not know what grade of steel was used, but if it were good for 80,000 lbs. per sq. in. the lateral pressure could not have been as much as one-fifth of the longitudinal pressure.

Mr. Ashcroft's advocacy of the closer spacing of rings and of wide rings leads to the conclusion that the best column is a steel tube filled with concrete. There is no doubt that this would make a strong column, but it is a composite column, with all that the term implies in the way of uncertainty in the distribution of stress, and not a reinforced concrete column. There are objections to such a column for ordinary use that it is needless to mention.

The objection to a flat bar in reinforced concrete is that the holding power of concrete is due to its gripping the steel, rather than mere adhesion. The concrete tends to shrink away from the side of a broad flat bar, whereas it grips firmly a small square or round bar. Further, the concrete on the outside of a broad flat bar near the surface may be easily knocked off. Some years ago I observed some reinforced concrete beams in which the reinforcement was a number of flats, which were brought up and hooked over the flanges of steel beams. The concrete below the bars fell off in large chunks when the forms were removed.

The objection to longitudinal steel in a column, that is, to the counting upon it as taking part of the column load, is that this, too, makes the column a composite structure and not a reinforced concrete column.

I cannot see any objection to lack of rigidity, as it is called, in a column, that is, to a column that will shorten a proportionately large amount under load. Wooden columns with a safe load of 1,000 lbs. per sq. in. and E = 1,000,000 will shorten three times as much as steel columns at 10,000 lbs. per sq. in., E = 30,000,000, but wooden columns are not objectionable merely on this account. In a beam rigidity is very essential, as the deflection can be felt or readily measured; but a little additional deflection in a column cannot be detected without the most careful measurement. An explanation of the lack of rigidity in reinforced columns as observed in the Watertown Arsenal tests is found in the tendency of concrete to shrink in setting. It does not seem to me to be necessary to assume that fissures occur, on this theory, as suggested by Mr. Howard [in Eng. News, July 5, 1906]. The tendency to shrink may be there and may be offset partially by the steel embedded. The concrete is then like a spring which is held from contracting quite down to its normal length by the steel. Again the tendency to shrink away from coils or hoops would make a swelling out of the column [due to the load] necessary before the coil is brought into action.

Mr. Ashcroft says, "In a reinforced beam we place the metal where it will resist the tensile stresses, leaving the plain unreinforced concrete to take care of the compressive stresses of 500 lbs. per sq. in. or greater." This is exactly what we ought to do with columns. A short block one or two diameters in height could safely be loaded to 550 lbs. per sq. in., but a plain concrete column, if loaded to this amount, is apt to break suddenly by bulging or flexure. The coils and longitudinal rods are used to overcome this weakness, just as the reinforcing rods in a beam are used to overcome the weakness of the beam in tension. The strength of the concrete in either case is practically that of concrete in short blocks.

Confined in a cylinder, concrete [or even loose sand] has a very great power for carrying loads; but while this fact is very useful in some lines it has little bearing on reinforced concrete design.

Has Mr. Ashcroft's experience with sand jacks shown him that the sand issues from the gate with a pressure approaching six-tenths of the unit load upon it? Would he design the walls of the jack for this pressure?

Yours very truly,

Edward Godfrey.

Monongahela Bank Bldg., Pittsburg, Pa., Aug. 31, 1906.

[In connection with the explanation, above offered, of the compressibility of concrete columns

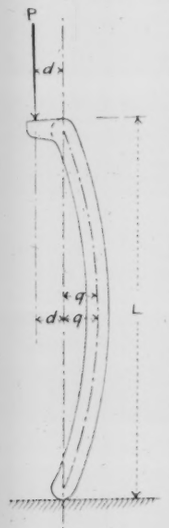
in certain cases, the old fallacy that two springs combined in opposition are more sensitive than a single spring recurs to mind. Really, the stiffness of two springs, whether in opposition or in parallel, is the sum of their individual rigidities, as a diagram will readily show. Now, applying this to the reinforced concrete, we have the concrete in tension due to shrinking, and the steel in compression to an equal amount. The rigidity of the combination, that is, the load required for unit compression, is just as great under these circumstances as of both steel and concrete were initially unstressed. The only case in which there is an exception to this rule is when there is a certain range of inelastic motion, or when the elastic system is changed at a given period; the former is instanced by local crushing at the bearing surfaces, the latter by loose fit of one of the elements which operates to keep it free from load until a certain compression is reached.—Ed.]

On the Analysis of Columns.

Sir: While preparing some lectures on the mechanics of materials the writer was recently very much struck (as were all the authorities he consulted, from their own confession) by the lack of a rational long column formula, and the very wide discrepancy between the results given by the various expressions that have been from time to time devised for column design.

After some little work I arrived at a solution of the difficulty which, if it is correct, is most admirable from the designer's standpoint, and apparently it has the further merit of being perfectly rational, and absolutely independent of all empirical factors. At the same time it gives results differing considerably from those usual in practice, and on this account, I am reluctant to propose it in college classes without its being discussed by some one not biased in its favor. I therefore beg that you allow the matter to be discussed in your valuable columns, and that some, at least, of your readers give it their consideration, without first condemning the formulas I shall develop on the ground that the treatment is not in accordance with Rankine.

In order to derive our formulas, we will assume a long column of some elastic material, and having a slightly eccentric load, but centrally supported at the other end, as in the sketch herewith. There



P is the load, d is its eccentricity, and q is the greatest deflection produced in the column by this load P. The moment of the load about the axis of the column is $P(d+q)$, and this moment produces a compressive stress on the concave side of the column, which is in addition to the uniform compressive stress due to the load itself. The amount of this stress may be found by the formula $f_1 = M/Z$, where f_1 is the stress due to the moment alone, M is the moment, and Z is the section modulus of the column. This expression will reduce to the form

$$f_1 = P(d+q)e/I$$

where I is the moment of inertia of the section, and e is the distance from the axis of the column to the outermost fiber in compression. The uniform stress due to the load is $f_2 = P/A$ where A is the area of the cross section of the column.

Now from Euler's equation, we have for the axial load which will hold a long column in equilibrium, with any given deflection q, $W = kEI/L^2$ where W is the axial load required to maintain a given deflection, k is a rational constant depending on the end-conditions of the column, E is the modulus of elasticity of the material, and L is the length of the column. We know that the moment of the eccentric force which maintains a given deflection q, must be the same as the moment of the load W. Therefore

$$P(d+q) = Wq$$

and $$q = Pd/(W-P)$$

also $$d+q = Wd/(W-P)$$

Substituting this value of $d+q$ in our first equation, we have

$$f_1 = PWde/(W-P)I$$

Adding the uniform stress, we have for the maximum stress

$$f = P/A + PWde/(W-P)I$$

or $$f = P/A[1 + Wde/(W-P)r^2]$$

where r is the radius of gyration of the section.

If we substitute for W in the above equation its value as found by Euler's formula, we will have an equation which will give us the value of the maximum stress in a column loaded eccentrically, provided that the stress does not exceed the elastic limit of the material. All the unknowns except the one we are seeking to find will have disappeared, and all the constants involved are rational. Our equation becomes

$$f = \frac{P}{A}\left[1 + \frac{kedEI/L^2}{[(kEI/L^2) - P]r^2}\right]$$

Simplifying this equation, it becomes

$$f = \frac{P}{A}\left[1 + \frac{kedEA}{(kEI) - (PL^2)}\right]$$

Although most columns are designed on the assumption that the load is axial, we know that this is not really the case. The line of application of the force does not necessarily correspond exactly with the geometric axis of the column, nor does the elastic axis correspond with the geometric axis. Therefore every load will have a very slight eccentricity, and the formula will apply to every case. Let us take the case of a column of known proportions and apply a gradually increasing load with an indefinitely small eccentricity. The numerator of the fraction within the brackets also becomes indefinitely small, and unless the denominator does also, the stress in the column is at all points sensibly equal to P/A. As the load gradually increases, it will finally reach such a value that the denominator of the fraction also becomes indefinitely small, which occurs when P approaches the value kEI/L^2. The slightest increase in the load will now give the fraction and therefore the whole expression an infinitely large value, and the column will fail by lateral deflection.

If the load reached this critical value without the uniform stress P/A exceeding the elastic limit of the material, the expression $P = kEI/L^2$ gives the exact value of the load which will produce rupture. If, however, the load is so great that the uniform stress exceeds the elastic limit, the modulus of elasticity of the material is greatly reduced, and the expression is no longer applicable, since we do not know, and have no means of computing what the modulus really is. We therefore conclude that

(1) That the greatest stress produced in any column by a load less than the elastic strength of the column, and having an indefinitely small eccentricity, is equal to the load divided by the sectional area of the column, unless the load equals or exceeds the value kEI/L^2.

(2) If the load exceeds the value kEI/L^2 the column will fail by lateral deflection.

(3) If the load does exceed the elastic strength of the column, it will fail at a less load than kEI/L^2, by lateral deflection.

(4) If I be sufficiently large in proportion to L, the column will fail by crushing before the load has become sufficiently great to cause it to fail by lateral deflection.

In designing a column, we must take care of two things, namely, that the uniform stress P/A does not exceed the safe stress of the material, and that the moment of inertia is sufficient that the column will stand the load without lateral deflection. In order for it to be equally safe against either cause of failure, it must have the same factor of safety against each. The true factor of safety against crushing is equal to the elastic limit of the material, divided by the working stress. The factor of safety against lateral deflection is the load which would produce such deflection divided by the load actually occurring, or W/P. We will then have from the principle of equal safety,

$$F/f = W/P.$$

Now since $I/A = r^2$, and since $f = P/A$, we will have for the stress in the column at the instant previous to failure by lateral deflection,

$$f = kEr^2/L^2,$$

or, since r is the only quantity associated with the section itself,

$$r^2 = fL^2/kE$$

is an equation which determines the value of the square of the radius of gyration of a section of a column, which will fail by lateral flexure under a load producing a stress f. In order for this column to be as safe against flexure as it is against crushing it is only necessary to increase its radius of gyration until

$$r^2 = FL^2/kE$$

where r is the least radius of gyration that the column should have, F is the elastic limit of the material in compression, L is the length of the column, E is the modulus of elasticity of the material, and k is a constant depending on the end-conditions of the column. Taking π^2 as equal to 10, which it is very nearly, we have the following values for k:

Columns with one end fixed and one end free, like a heavy weight at the top of a flagpole, $k = 2.5$.

Columns with both ends pin connected, like a connecting rod, $k = 10$.

Columns with one end pin connected, and the other end rigidly fixed, $k = 22.5$.

Columns with both ends rigidly fixed, $k = 40$.

The preceding equation gave only the minimum value of the radius of gyration. In order to find the minimum value of the cross sectional area of the column, we must use the expression

$$A = P/f$$

where A is the area required, P is the axial load, and f is the safe working stress of the material.

These formulae have the very great advantage, from the designer's point of view that they each contain but one variable, and are in a form to be easily solved. A column designed by their use will, I believe, support by lateral flexure under that load which would produce a uniform stress equal to the elastic limit of the material. If the designers of experience decide that they do not give results large enough, the proper remedy is to use them, and to take a lower safe working stress, rather than to use an irrational formula and a large working stress. A column designed by this formula will have almost, but not quite, the same strength against failure by lateral deflection as would a column with a much larger radius of gyration. The actual strength of the larger column in service would be no greater.

The writer does not mean to say, however, that he would object to a column having a larger radius of gyration than that given by the formula. On the other hand he regards the addition as an excellent insurance against the ill effects of eccentric loads. On this account many designers would prefer to take F as the ultimate strength, instead of the elastic strength. But by so doing they must not think that they have increased the strength of the column against failure by lateral deflection in the same proportion.

Forrest E. Cardullo.

Syracuse, N. Y., Aug. 24, 1906.

[The results which Mr. Cardullo deduces may perhaps be put more directly in relation with the usual procedure of design by the following observation. Taking the author's final formula for radius of gyration,

$$r^2 = FL^2/kE,$$

we may transform it into

$$(L/r)^2 = kE/F.$$

For steel, E, the modulus of elasticity, is very closely 30,000,000 lbs. per sq. in. The elastic limit, F, may for soft steel be taken at 35,000 lbs. per sq. in. Taking the values of k which the author quotes, the above equation gives the following values of $L \div r$:

	L r
Column fixed at base, free at top	46
Column with both ends pin-connected	92.5
Column with one end fixed, one end pin-connected	139
Column with both ends fixed	185

Mr. Cardullo recommends: First, that in designing a column of given length, such a section be chosen as will make the value of length divided by radius of gyration equal to 46, 92.5, 139, or 185, depending on the end conditions, according to the above list; and second, that this section be given such an area that it will be loaded up to the full specified safe compressive stress of the material, for example 15,000 lbs. per sq. in. Under the methods in current use in designing, a column in which $L \div r$ is say 92.5 would be allowed only a much lower unit stress than the basal working stress in compression. If for example the formula employed were

$$p = 15{,}000/[1 + L^2 \div 13{,}500\ r^2]$$

then for $L \div r = 92.5$ the equivalent unit stress would be $p = 15{,}000 \div 1.635 = 9{,}180$ lbs. per sq. in. Mr. Cardullo proposes to use $p = 15{,}000$ lbs. per sq. in. for such a column; certainly a radical proposal. We leave the discussion of the proposed theory to our readers.—Ed.]

REPORT OF A LONDON ENGINEER ON SEWAGE DISPOSAL AT TORONTO, ONT.

It is unusual for a municipality to secure detailed advice on proposed engineering work from an engineer who has never been in the country, even, in which the municipality is located. A few years ago the city of Baltimore employed the late James Mansergh to report on sewage treatment, and during the present summer the city of Toronto, Ont., acting through Mr. C. H. Rust, M. Am. Soc. C. E., secured a report on the Toronto sewage problem from Mr. G. R. Strachan, M. Inst. C. E.* When Mr. Mansergh was engaged by the city of Baltimore, the rapid bacterial methods of treatment were new, and his report consisted very largely of a review of the whole subject as it then stood. Since that time there have been great advances in sewage treatment, both abroad and at home. Engineers

*9 Victoria St., Westminster, London, S. W., England.

from this side of the water, however, are still going to England in considerable numbers, to inform themselves at first hand regarding the latest developments there. It was in connection with such a trip that Mr. Rust arranged with Mr. Strachan to make a report for Toronto. A number of conferences between the two engineers took place while Mr. Rust was in England.

The population of Toronto is now about 270,000. A population of 300,000 was accepted by Mr. Strachan as a basis for his report. Sewer gagings in the early part of 1900 indicated a total daily sewage flow of about 30,000 U. S. gals., of which some two-thirds was discharged into the harbor and the balance into Garrison Creek. The water supply of Toronto, which is perhaps the chief object of concern in connection with sewage disposal, is taken from the lake outside the harbor, at a depth of 70 ft. It is not filtered, and has not even the advantage of sedimentation due to storage. The average daily per capita consumption of 120 U. S. gals. seems to Mr. Strachan "extraordinarily large."

It has been proposed by Mr. Rust that crude sewage be delivered into Lake Ontario 3 miles eastward of the city limit and 9 miles from the water intake, the discharge to take place 2,250 ft. from the shore, at a water depth of 25 ft. Mr. Strachan considers that the high water consumption at Toronto results in a sewage about the strength equal to three times the dry weather flow, requiring treatment under the rules of the Local Government Board. The Board permits storm water in excess of six times the dry weather flow to be discharged without treatment. Following this general reasoning, Mr. Strachan states that any sewage flow at Toronto in excess of 240 U. S. gals. per capita "may properly be allowed to go untreated into the nearest outlet into the lake or harbor without nuisance or sensible pollution." He advises that all sewage, before its discharge into the lake, should be passed through "three sets of mechanically worked fixed screens with decreasing meshes." As to the effect of discharging screened crude sewage into the lake, he states that doubtless the water will be "discolored and objectionable" for a few hundred yards around the submerged outlet, but thinks "there will be no nuisance worth speaking about." He is also of the opinion that "the lake will digest the pollution with the aid of the bacterial life brought into being by the discharge."

Although endorsing Mr. Rust's scheme for the discharge of crude sewage into the lake, Mr. Strachan reviews briefly and interestingly disposal on land and also by either contact or sprinkling beds, septic tanks to be used in either case, and the tanks alone to be used during the four cold months of the year if land disposal should be adopted. As to the combination of septic tanks and land disposal, Mr. Strachan states emphatically, at the outset, that unsatisfactory results might be expected, particularly "as to the discharge of the septicised effluent." A portion of Mr. Strachan's remarks on the septic tank in relation to land disposal may be quoted as follows:

It is now known, and not disputed, that there is with sewage of the strength we have here, a very foul residue from the septic process, which, when the tanks hold one day's dry weather flow, amounts each year to one-sixth of the contents of the tank or thereabouts.

There can be little doubt that the processes of septicising go on as efficiently in an uncovered tank as in one that is covered, when once the scum has formed and remains intact. The Toronto tanks were to be covered for climatic reasons, and therefore the issue does not, strictly speaking, arise in this case, but it may be well to state that the odors from open septic tanks have been abominable in several cases of nuisance I have investigated. There are open tanks without offense such as those at Birmingham, but the sewage there is much mixed with trade wastes, which seem to give it an impunity in this respect. In every case of open tanks I know of, where the sewage is domestic, offense is present and often in a pronounced form. The trouble arises in three ways. There is first and continuously the ebullition of new septic sludge through vents in the scum, which give off putrid odors when drying in the air and sun. There is second, and frequently, the wetting of the scum by rain and the subsequent bad smells during evaporation and absorption. Then a third and less frequent offense is caused by the wind compressing the scum into a more solid mass and leaving part of the septicised sewage exposed. It happened that at the time of Mr. Rust's visit I was investigating a case where these evils were the cause of nuisance. We visited the works and he experienced for himself the offenses I have indicated.

There is now no serious contention here that septicised effluents should have their putrescence corrected by ærobic bacterial treatment before being applied to land. Quite recently two cases on a small scale have passed through my hands where the uncorrected septic effluent was put on land, and in both cases the offense of putrid sewage was very marked. This must be the result when the conditions are realized. A septic effluent is one in which the anærobic organisms have turned the sewage into a putrid condition, and when such a liquid is applied to land in a thin film the exposure must and does produce ærial nuisance. In my practice, septicised effluents are conducted in covered pipes and channels to the ærobic beds to avoid the nuisance of even so short an exposure. I have been engaged in most of the cases of nuisance from septicised sewage which have been in the Courts here, and in every one the exposure of the liquid has been a main contributor to the offense. I have no doubt that ærial nuisance would ensue if the proposal now under discussion is carried out.

The scheme can, however, be modified to meet this objection. I suggest that the tanks be reduced in volume to hold three or four hours' flow, which will enable the heavier suspended particles to subside, and will not give time for the sewage to be septicised. The sludge would have to be removed from the tanks twice a week, and should be pressed into cake or dug in. The clarified sewage could then be applied to the land without nuisance. I know of no case where sewage is disposed of at a greater rate than 30,000 gals. [36,000 U. S. gals.] per acre per day, and even when one allows for the dilute character of your sewage I do not think the ultimate flow of 50,000,000 gals. [60,000,000 U. S. gals.] per day can be properly dealt with on less than 1,200 or 1,500 acres, and even more land might be necessary.

In discussing contact and sprinkling beds, Mr. Strachan states that the present-day tendency is to favor the latter; but nevertheless he believes that, the year round, contact beds are most advantageous, particularly for Toronto, since they are not so much affected by cold weather as are the sprinkling or percolating filters. The latter, he believes, would have to be covered at Toronto, "to protect the operating and distributing parts from freezing and to maintain the vitality of the bacterial life in winter," and he adds that "probably the air might have to be warmed."

Calculations for the cubical contents of either class of beds, the report states, should be based on a volume "of clinker equal to the daily volume of the dry weather flow of sewage."

As to the relative cost of the three schemes of disposal, Mr. Strachan says:

Although I have not worked out the estimates, yet I venture the opinion that both in capital cost and operating expenses the scheme for discharging the sewage into the lake will be the most economical of the three, that the filtration scheme will come next, and the bacterial scheme will prove the most costly. The maintenance expenses for up-keep of the plant and works will also follow the same order.

The final part of the report relates to the several schemes as affecting the water supply. Contrary to the evident opinion existing in Toronto, Mr. Strachan considers it as by no means certain that either land disposal or rapid bacterial treatment would protect the water supply from all risk, assuming in particular that during four months of the year sewage subjected to treatment in septic tanks, only, would be discharged into the lake 4½ miles east of the water supply intake. The closing remarks on this subject, and of the report as well, are as follows:

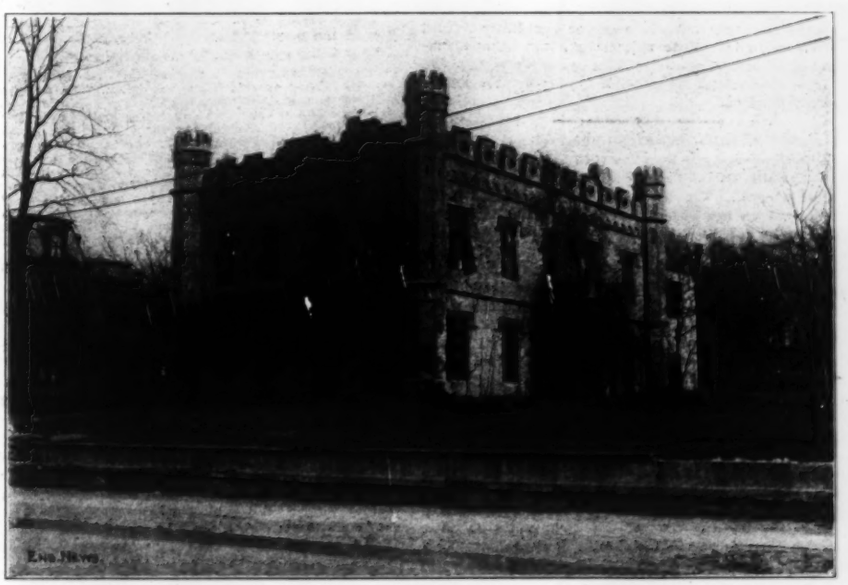
In my judgment the discharge of crude screened sewage nine miles east of the intake contains so remote a risk to the water supply as to make the scheme a reasonable and proper one. It is to be remembered that the movement of the water in the lake is slow, that the suspended matters soon settle, that the bacterial life is rapidly reduced by exposure to light and air and by the bactericidal agencies, and that the microbes undergo a loss of vitality in water. I cannot bring my mind to the conclusion that either suspended matters or bacteria from the sewage will reach the zone feeding the intake.

The effect of the effluent from the land filtration scheme is very difficult to gage. It may all go into the Don and so into the harbor, or into streams leading to Ashbridge's Bay. This scheme, however, is one for dealing with the dry weather sewage only, and it does not provide in any way for the increased flow from the rainfall, which would continue to be discharged as now. In my opinion there is less risk from the effluent considered by itself than in the crude sewage scheme, but when the smaller volume dealt with is considered, and the consequent greater pollution of the water by more frequent overflow is brought into the account, I hesitate to put it as the safer of the two. At the same time I can describe it as a reasonable and proper scheme.

As regards the tank and contact scheme, I feel bound to say that while the risk to the water is remote, yet it is, in my view, more real than in the other schemes. It, too, deals only with the dry weather flow, and consequently there is more pollution from overflow than in the first proposition. Seeing that this scheme is the most costly, it may be regarded as the least favorable of the three, although it is a good proposal in itself.

The choice seems to lie between the crude sewage discharge and the land filtration scheme, and having as an expert discharged my task, in advising that the cost of the first is less than that of the second, that the remote risks to the water supply are on a parity, and in indicating my preference for the former scheme, I leave the selection to the Council and the citizens without further comment.

I cannot, however, close this report with comfort, without a digression to the water question. I know that voluntary advice generally meets with short shrift, yet I must express anxiety at the absence of filtration. With us filtration is so much used, even for our upland schemes, that its omission in the circumstances at To-



THE OLD WARD CASTLE, NEW BRIGHTON, STATEN ISLAND.
(See page 264.)

ronto has the effect of a shock on one's mind. The huge user of water undoubtedly operates as a hindrance to the adoption of filtration, by reason of the enhanced cost of the very large area of sand for filtering 100 gals. [120 U. S. gals.] per head per day, but notwithstanding that exaggerated burden I commend filtration as a prudent safeguard. Should the undue cost of the filters lead to the prevention of the waste now going on, so as to bring the financial burden within the usual limits, that would be a double advantage gained by filtration.

A HOUSE CONSTRUCTED IN 1835 OF CONCRETE BLOCKS.

The accompanying cut (p. 263) shows, as it appears to-day, what was doubtless the first building in New York, if not in the United States, to be constructed of concrete blocks. This building, known as the old Ward Castle, located at Richmond Terrace, New Brighton, N. Y., was the first large and fine residence to be erected on the north shore of Staten Island. It was built about 1835 by Geo. A. Ward, a New York banker, and at that time was considered quite a curiosity on account of the material used in its construction.

The concrete blocks are still solid and show but little the effects of weathering for three-quarters of a century, the corners and ornamentation being the only parts that have been eroded. The blocks were made on the ground and evidently natural cement was used in their construction, while the ornate parts were apparently molded into blocks and then laid up in the walls. It is apparent that no effort was made to disguise the fact that the building material was concrete and not stone, as is so frequently the case in these days. The building, although it has not been in use for years, is still in a fairly good state of preservation, and gives some indication of the stability of concrete block construction.

THE OVERSEAS LIMITED is the name of the new train that has been put on by the Canadian Pacific Ry. to connect with the Pacific and Atlantic Empresses steamships. By this arrangement travelers can go from Liverpool, England, to Hongkong, China, on one ticket, with baggage checked through. Only two changes will be necessary, one at Quebec, Ont., and the other at Vancouver, B. C. The journey of 12,004 miles will be made in 30 days, according to the schedule, which is five days shorter than the time by present route: Brindisi, Suez Canal and P. & O. steamers. The mails will also be carried by this route.

THE JAMESTOWN TER-CENTENNIAL, which is to be held on the shores of Hampton Roads, Va., in 1907, is intended to illustrate, by graphic representation, the industrial growth of the United States during the last 300 years. Modern machinery, textile goods, furniture, engines, etc., will be displayed, while in way of contrast there will be reproduced an old-time village, consisting of buildings of colonial architecture in which metals, woods, and fabrics will be wrought by the methods of the early colonists. The exposition is to be conducted under the same general rules and regulations as previous ones, with the exception that where former expositions refused admittance to inventions unless they were being manufactured or on sale, the Jamestown exposition will receive all inventions offered for exhibition, whether they are on the market or not.

TWENTY-THREE HUNDRED-VOLT, THREE-PHASE induction motors have been installed in the three mills of the Joslyn Mfg. Co., of South Scituate and Hope, R. I., for auxiliary power. The Richmond and Ponogansett mills are located on the Ponogansett River, about two miles apart, while the Rockland mill is situated between the two above mills, and lies about three-quarters of a mile above the Ponogansett mill. The Rockland mill embraces a small power-house in which is installed a 200-KW., 2,300-volt, three-phase, water-wheel driven General Electric generator and switchboard. This power plant supplies power to operate the Rockland mill, and also the Richmond and Ponogansett mills when necessary. The Richmond mill is ordinarily driven by water power, the water-wheel at the same time driving a 75-KW. belted machine, which runs in parallel with the 200-KW. machine of the Rockland mill. If, however, the water becomes low this machine operates as a synchronous motor to drive the mill, and then receives current from the 200-KW. generator. At the Ponogansett mill a 100-KW. machine is arranged to operate in a manner similar to that of the Richmond mill. The motor frames, as well as the sheaths of the cables, which are laid in iron conduit, are connected to earth to avoid all danger, should the high voltage cables become grounded.

WATER SUPPLY AND FIRE PROTECTION AT DENVER, Colo., has been reported upon by the Committee on Fire Protection of the National Board of Fire Underwriters (135 William St., New York City). In general, the water supply is well spoken of, except that some of the main arteries are "poorly connected to each other and to the distribution system," and that many of the distributing mains are too small. The fire department is said to be under good supervision, but all the companies are undermanned, the fire engines are too few, a number of them are too small and of an unreliable type, and the reserve engines are unserviceable. The ladder and chemical service and the minor equipment are incomplete, and the engineers and assistants are poorly drilled. The discipline is good. The fire alarm system, as a whole, is physically inadequate, but its maintenance is good. The conflagration hazard is described as follows:

Severe in the congested value district on account of the close grouping of conflagration breeding blocks, which are mainly compactly built with structurally weak risks mutually exposed across narrow alleys, the limited strength of the fire department and the unreliable fire alarm system. No serious hazard outside the main district.

THE NEW RATE LAW, which places all railroads, persons or corporations engaged in interstate commerce under the control of the Interstate Commerce Commission, went into effect at midnight Aug. 27. The new law requires that schedules of rates and charges be filed with the Commission and posted at all stations, and also stipulates that these rates and charges cannot be changed except after a 30 days' notice to the Commission and to the public. These schedules must not only show the full cost of transportation from point to point, but also what items go to make up this cost, so that a shipper may obtain in advance a complete statement of the charges he will have to pay. In other words, the posted schedules must include all charges, such as transportation, icing, elevators and sidetracks. The new law also requires that a uniform system of accounting be established and that the books of these carriers be always open to the expert accountants of the Commission. Failure to obey the law makes the transgressor liable to a heavy fine.

THREE NEW FERRY BOATS have been ordered by the Department of Docks and Ferries of New York City for service between the Battery, Manhattan, and 39th St., Brooklyn. Each boat will be of steel construction, 209 ft. long, with a 45-ft. beam, and will be made with five transverse water-tight steel bulkheads and fitted with steam and hand-steering gear. A definite speed or horse-power is not called for in the contract, but the specifications were drawn with the idea of obtaining a speed of 15 miles per hour with an output of 200 HP. Each boat will be provided with two two-cylinder compound engines and screw propellers at each end of the boat. Harlan & Hollingsworth Co., of Wilmington, Del., was awarded the contract for building the boats, their bid being $635,000.

AN IRRIGATION PUMPING PLANT in the Arkansas Valley, near Garden City, Kan., was authorized in September, 1905, by the Secretary of the Interior. The plant is designed to supply water to the Farmers Ditch. Contracts have been let and the work of construction of this project is now under way under the supervision of the U. S. Reclamation Service. Prof. Charles S. Slichter, of Madison, Wis., who made an extensive investigation of the movement of the underground waters of the Arkansas Valley, is quoted as saying:

The stimulus given to this part of the Arkansas Valley by the proposed pumping plant has greatly developed the installation of pumping plants by private parties. The census recently taken shows that 162 privately built pumping plants have been put in service in the Arkansas Valley within the last twelve months. A large number of these pumping plants are operated by gasoline engines. A few that have been installed at Rocky Ford, Colo., use hard coal in gas generators which supply gas engines. These gas plants at Rocky Ford show very remarkable results in the production of power at low cost. A test of a 35-HP. pumping engine at Rocky Ford for ten days during the month of May, 1906, showed that the cost of coal per hour averaged but 7 cts. At this place the fuel used costs $6 per ton at the ranch.

AN INTERESTING PATENT DECISION was rendered by the High Court of England a few weeks ago in Davidson vs. The Sun Fan Co., a suit alleging infringement of the patent on the "Sirocco" fan. The patent involved in the case claimed a ring of vanes of radial depth "not greater than about one-eighth" of the diameter of the fan-wheel. The fan of the defendants had vanes one-sixth their outside diameter in depth, and the court held that the case turned on the question whether or not this proportion is covered by the terms of the patent. It decided that "the patentee does not bind himself to exactly one-eighth. The test of whether one-sixth can be said to be about one-eighth must be whether the results produced are practically identical." Testimony was taken which showed that the action of the two fans was substantially identical, and decision was rendered in favor of the plaintiff.

PERSONALS.

Mr. O. A. Weidner has been appointed Assistant Superintendent of the Atlantic City R. R., with headquarters at Camden, N. J.

Mr. William Darbee, Expert of the New York Public Service Commission of Gas and Electricity, has resigned to become General Manager of the Albany & Hudson R.

Mr. W. W. Allen, formerly connected with the Buffalo Iron Works, of Hilburn, N. Y., has been made Manager of the Wier Frog Co., of Cincinnati, Ohio, to succeed Chas. Partington, resigned.

Mr. Robert Follansbee has been placed in charge of the hydrographic work of the U. S. Geological Survey in the district comprising North Dakota, Montana and parts of Wyoming. He succeeds Mr. H. M. Morse, resigned.

Mr. Geo. H. Meck, Assistant City Engineer of East St. Louis, Ill., has resigned to become Engineer for the Williams Lumber Co., of Leslie, Ark. Mr. P. B. Lewis has been appointed to the position made vacant by Mr. Meck's resignation.

Obituary.

William C. Squier, for many years President of the Passaic Zinc Works, died at his home in Rahway, N. J., aged 94 years.

John E. Aldrich, a contractor of Aquebogue, L. I., died at his home in that place, Aug. 29, of heart disease, aged 65 years.

Henry A. Hitner, formerly President of Henry A. Hitner's Sons, of Philadelphia, Pa., dealers in contractors' equipment, died at his home in that city, Aug. 28, aged 50 years.

William Buck Dwight, Professor of Geology and Mineralogy at Vassar College, Poughkeepsie, N. Y., died at Cottage City, Mass., Aug. 29, of apoplexy. He was born at Constantinople, Turkey, May 22, 1833.

Jones M. Jackson, M. Am. Soc. C. E., a contracting engineer of Schenectady, N. Y., died suddenly Aug. 31. He was formerly Chief Engineer and General Superintendent of the Baltimore & Eastern Shore R. R.

E. S. Wills, formerly Superintendent of the Atchison Water Co., and one of the first civil engineers to be employed by the Chicago, Burlington & Quincy Ry., died at his home in Atchison, Kan., Aug. 27, 73 years of age.

E. T. Hannam, Assistant Manager of Sales of the Water Tube Boiler Department of the Atlas Engine Works, died at Chicago, Ill., Aug. 18, of heart disease. Mr. Hannam was the inventor of the Atlas water tube boiler and was well known in engineering circles.

ENGINEERING SOCIETIES.

COMING MEETINGS.

THE NEW ENGLAND WATER-WORKS ASSOCIATION.
Sept. 12-14. Annual Convention at Fabyan House, White Mountains, N. H. Secy., Willard Kent, Narragansett Pier, R. I.

AMERICAN PUBLIC WORKS ASSOCIATION.
Sept. 14-15. Second Annual Meeting at Atlanta, Ga. Secy., W. H. Flint, Chattanooga, Tenn.

LEAGUE OF AMERICAN MUNICIPALITIES.
Sept. 26 to 28. Annual convention at Chicago, Ill. Secy., Jno. MacVicar, Des Moines, Iowa.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Oct. 2 to 5. Annual Meeting at Birmingham, Ala. Secy., G. W. Tillson, Municipal Bldg., Brooklyn, N. Y.

AMERICAN ELECTROCHEMICAL SOCIETY.
Oct. 8-9. Annual meeting at New York City. Secy., S. S. Sadtler, 39 South 10th St., Philadelphia, Pa.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION.
Oct. 15 to 19. Annual Convention at Columbus, Ohio. Secy., Bernard V. Swenson, 60 Wall St., New York City.

THE RAILWAY SIGNAL ASSOCIATION.
Oct. 16-18. Annual Meeting at Washington, D. C. Secy., H. S. Balliet, Grand Central Station, New York City.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—The summer excursion of the society will occupy nearly the whole month of September. The party will leave Montreal Sept. 8, arrive at Winnipeg Sept. 10, Vancouver Sept. 15 and Grand Forks Sept. 19. Returning the party will leave Grand Forks Sept. 21, after having taken a short trip to Phoenix and Greenwood, by the way of Nelson, arriving at Winnipeg Sept. 25, Montreal Sept. 29. Both going and returning the party will make numerous stops at the intermediate stations.

THE ST. LOUIS RAILWAY CLUB.—The club has decided to establish a $250 scholarship at the University of Missouri. All candidates for the scholarship must be sons of members of the club, and must be recommended by three other members of the club. The Executive Committee of the club will select from the applicants for the scholarship one candidate and two alternates. The candidate must then pass his entrance examination for the university and matriculate. If he fails the first alternate will be given a chance, and if he fails the second alternate will be tried. The scholarship can be revoked at any time by the club for improper conduct or poor standing of the student.